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MC REPORT 003
Volume 2

AD517075

Appendices

THE PARKA I EXPERIMENT

January 1971

OCEAN SCIENCE PROGRAM
MAURY CENTER FOR OCEAN SCIENCE
Department of the Navy
Washington, D.C.

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MC Report 003
Volume 2

Appendices

LONG RANGE ACOUSTIC PROPAGATION PROJECT

THE PARKA I EXPERIMENT

PACIFIC ACOUSTIC RESEARCH KANEOHE-ALASKA

JANUARY 1971

OCEAN SCIENCE PROGRAM
MAURY CENTER FOR OCEAN SCIENCE
Department of the Navy
Washington, D.C.

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CONTENTS

On behalf of Navy Managers responsible for the PARKA I experiment, the contributions of senior officers of the Navy, members of the scientific community who participated in PARKA I, and seafaring men, both naval and civilian, who contributed in various ways to the experiment are gratefully acknowledged.

Vice Admiral C. B. Martell, USN (Ret.); Vice Admiral T. Caldwell, USN; Vice Admiral H. G. Bowen, USN; and other senior officers supported and encouraged the planning and execution of the whole PARKA series.

Dr. R. H. Nichols, Bell Telephone Laboratories, served as Chief Scientist, and in that role was responsible for the scientific planning and execution of PARKA I. Mr. R. W. Hasse, Navy Underwater Sound Laboratory, was the Deputy Chief Scientist. Mr. G. H. Fisher, Hudson Laboratories, served as Project Coordinator, and was assisted by Mr. K. W. Lackie in the coordination of oceanographic operations. Captain R. H. Smith, USN, and Lieutenant E. E. Flesher, USN, ASWFORPAC, directed naval aspects of the operations. Broad scientific planning was accomplished by a group including Dr. F. N. Spiess, Marine Physical Laboratory; Mr. W. Annis, Office of Naval Research; Mr. J. I. Ewing, Lamont-Doherty Geological Observatory; Dr. G. P. Woollard, Hawaii Institute of Geophysics; Dr. E. E. Hays, Woods Hole Oceanographic Institution; Mr. W. B. Randlett, Naval Oceanographic Office; Dr. J. C. Munson, Naval Research Laboratory; Captain Paul Wolff, Fleet Numerical Weather Central; and Mr. E. L. Smith, Navy Undersea Research and Development Center.

The Commanding Officer, Fleet Weather Central, Pearl Harbor, and his staff provided data handling facilities which acted as the necessary link between the data-gathering ships at sea and the data-processing facilities at FNWC. Commander, Fleet Air Wing Two and his staff and aircraft crews provided a most important series of quick looks at the ocean structure during the experiment, and are continuing to fly similar flights to obtain seasonal data. The Commanding Officers, Masters, and crews of the ships, and the commands responsible for platforms and shore stations participated, in most instances, continuously during the two-month period of the experiment; their attention to detail and ability to adapt to changing requirements provided the continuity and responsiveness necessary to meet the scientific objectives of the experiment.

Valuable administrative assistance in logistics, materiel procurement and schedule coordination was provided by Lieutenant Commander J. J. Holt, USN, and Mr. A. E. Molloy of the Office of Naval Research.

Obviously, many other individuals and organizations have contributed to the planning and execution of the experiment. Although it is not practical to list them all here, their contributions are most gratefully acknowledged.

J. B. Hersey

Director of Maury Center

This Report, like the PARKA I Experiment itself, was achieved by the cooperative efforts of many individuals from the organizations which participated. It is bound in two volumes. Volume I presents a description of the experiment, the results of the oceanographic and acoustic measurements, the predicted (computed) transmission loss characteristics based on a particular mathematical model, and a comparison of calculated and measured results.

Volume II comprises a set of Appendices which generally present information about the operations conducted and the results obtained by a number of the individual organizations. In many cases they amplify and extend in greater detail the material in Volume I. The authors of each Appendix in Volume II are identified by a by-line.

Acknowledgment is also due the several hundred individuals who contributed directly or indirectly to the Report through their participation in a multitude of ways in the PARKA I Experiment.

R. H. Nichols

R. H. NICHOLS
Chief Scientist, PARKA

Since both the PARKA I Experiment and the writing of this Report were accomplished through the cooperation of many individuals from several different laboratories and institutions, both Navy and private, many abbreviations and terms that were in common usage in the PARKA community may appear in the text or figures without being defined. Although every effort was made to define all new abbreviations as they occurred in the descriptive portions of the report (Appendices B, D, E, and F), it is inevitable that a few undefined terms or acronyms slipped past the editors into the text. In this Report, different Appendices deal with totally disparate subjects, consequently, the reader may encounter an unfamiliar term that was defined only in an earlier section that he did not read.

In the interest of conserving space, no attempt has been made to spell out all potentially unknown abbreviations every time that they appeared, or to define repeatedly the many acronyms in the text. In addition, Appendices A and C, are Event Logs that contain few definitions since they will be consulted only by someone seeking detailed information of an operational nature who already knows the terminology.

Therefore, although most definitions appear several times in the text, Table I listing the acronyms and abbreviations most commonly used in this Volume is included here to assist the reader.

Table I – Definitions of PARKA Acronyms and Abbreviations (U)

AC – alternating current
A/D – analog to digital
ALFA – The FLIP/SANDS position; nominally 27°30′N, 157°50′W. Positions are given as plus (north) or minus (south) of ALFA, BRAVO, and CHARLIE
AM – amplitude modulation
APL – Applied Physics Laboratory of Johns Hopkins University
ART – airborne radiation thermometer
ASWFORPAC – Antisubmarine Warfare Force, U.S. Pacific Fleet
avg – average
AXBT – airborne expendable bathythermograph
BATHY – message format used to transmit bathythermograph data
BCF – Bureau of Commercial Fisheries
BRAVO – the halfway point of the PARKA I track, 43°N, 157°50′W
BT – bathythermograph, an instrument which measures temperature versus depth in the ocean
°C – temperature in degrees Celsius or Centigrade
CDM – continuous data mode
COMEX – commence exercise
CHARLIE – the northern end of the PARKA I track, 55°N, 157°50′W
CW or cw – continuous wave
dB or db – decibel

Table I – Definitions of PARKA Acronyms and Abbreviations (U) (Continued)

DC – direct current
ESSA – Environmental Science Services Administration, Department of Commerce
°F – temperature in degrees Fahrenheit
FINEX – finish exercise
FM – frequency modulation
fm – fathom(s)
FNWC – Fleet Numerical Weather Central
FWC – Fleet Weather Central, Pearl Harbor
GDR – Gifft Depth Recorder
GMT – Greenwich Mean Time (Zulu time)
HF – high frequency
HIG – Hawaii Institute of Geophisics, University of Hawaii
HISTD – message format used to transmit oceanographic data containing temperature, salinity, or sound velocity as a function of depth
H-1, H-2, etc – hydrophones on FLIP
hr – hour(s)
Hz – Hertz, or cycles per second
IES – inverted echo sounder
I/O – input/output
ips – inches per second
IRIG – Inter-Range Instrumentation Group
K – thousand
kHz – Kilohertz, or thousands of cycles per second
Km or km – kilometer(s)
km/sec – kilometers per second
Kt or kt – knot(s)
kyd – kiloyard or 1,000 yards
m – meter(s)
MHz – Megahertz, or millions of cycles per second
MILS – Missile Impact Location System (hydrophones which are part of the Pacific Missile Range System)
min – minute(s)
MK or Mk – Mark, followed by a number, Navy designation for type of SUS charge
MPL – Marine Physical Laboratory, Scripps Institution of Oceanography
msec – millisecond, or thousandths of a second
m/sec – meters per second
μbar – microbar of pressure
μf – microfarad, unit of capacitance
N – north latitude
NAVOCEANO – Naval Oceanographic Office

Table I – Definitions of PARKA Acronyms and Abbreviations (U) (Continued)

NM or nm – nautical mile(s)
NRL – Naval Research Laboratory
NURDC – Naval Undersea Research and Development Center, San Diego
OCC – Operation Control Center (PARKA command post) located at the Pacific Missile Range Facility, on the Marine Corps Air Station, Kaneohe, Hawaii
OCE – Officer conducting the exercise
ONR – Office of Naval Research
PARKA – Pacific Acoustic Research Kaneohe – Alaska
PARKA I Track – The meridian 157°50'W from 22°N to 55°N
PDR – Precision Depth Recorder
PESR – Precision Echo Sounder Recorder
PMR – Pacific Missile Range
PN – pseudo-random noise
psi – pounds per square inch pressure
QRM – radio interference
RC or rc – resistance-capacitance
rf – radio frequency
RMS – root mean square
rpm – revolutions per minute
SEAMAP – an ESSA project which surveyed the central North Pacific Ocean
SIO – Scripps Institution of Oceanography
S/N – signal-to-noise ratio
S+N – signal-plus-noise
SOA – speed of advance
SOFAR – sound fixing and ranging
SOFAR axis – Same as sound channel axis
sound channel axis – the depth in the water column where the speed of sound reaches a minimum
SOVEL – sound velocity
SST – sea surface temperature
STD – salinity-temperature-density (depth) profile
SUS – Signal, Underwater Sound; a small explosive charge
SVP – sound velocity profile or sound velocimeter system
°T – degrees true (corrected for magnetic anomolies)
UQN – standard Navy echosounder
USC&GS – U.S. Coast and Geodetic Survey
USL – Underwater Sound Laboratory (same as USNUSL)
USNUSL – U.S. Navy Underwater Sound Laboratory
USOC – Undersea Surveillance Oceanographic Center, Naval Oceanographic Office
V – volt
VDS – variable depth SONAR

Table I – Definitions of PARKA Acronyms and Abbreviations (U) (Continued)

vs – versus
W – (used with a position) – west longitude
W (used with a time) – Whiskey, or Hawaii Local time (GMT + 10)
WHOI – Woods Hole Oceanographic Institution
WWV – time standard radio station operated by Bureau of Standards, Department of Commerce
XBT – expendable bathythermograph
Z – Zulu, or Greenwich Mean Time

Since ship names appear somewhat randomly throughout the text, the following is a list of the various units involved in PARKA I, with their affiliation during this Experiment:

1. USNS SANDS (AGOR-6): Navy Underwater Sound Laboratory
2. R/V FLIP: Marine Physical Laboratory, Scripps Institution of Oceanography
3. R/V CONRAD: Lamont-Doherty Geological Observatory
4. USS MARYSVILLE (PCER-857):
   a. Phase 0: Naval Undersea Research and Development Center
   b. Phases 1 and 2: Woods Hole Oceanographic Institution
5. USS REXBURG (PCER-855): Naval Undersea Research and Development Center
6. R/V MIKIMIKI: Hawaii Institute of Geophysics, University of Hawaii
7. M/V PACIFIC APOLLO: Marine Physical Laboratory, Scripps Institution of Oceanography
8. USS RADFORD (DD-446): Navy Underwater Sound Laboratory; Naval Research Laboratory
9. R/V TERITU: Hawaii Institute of Geophysics, University of Hawaii
10. Monster Buoy: Scripps Institution of Oceanography
11. Aircraft (airborne expendable bathythermographs): Patrol Squadron 28; Commander, Antisubmarine Warfare Force, Pacific
12. Aircraft (airborne radiation thermometer): Naval Oceanographic Office.

A complete description of the PARKA I Experiment is contained in Volume I of this Report. A brief review of the rationale behind the various ship and aircraft movements is presented in Parts 1 and 2 of Appendix B of this volume.

Appendix A (C)

PARKA I NARRATIVE LOG, PHASES I AND II

G. R. Fox and H. J. Young
Bell Telephone Laboratories

The major points of the experimental operations at sea during Phases 1 and 2 of PARKA I are outlined below in chronological order, and track charts for all participating vessels are appended (Figs. A-1 through A-14). Details of individual organizations' operations may be found in the other Appendices which follow.

1. Phase 1

a. Preparations

(1) Ship Departures

9 August 0800W	SANDS departed Honolulu for test of navigation equipment and to rendezvous with PACIFIC APOLLO and FLIP at 27°30′N 157°50′W.
1600W	PACIFIC APOLLO took FLIP in tow and departed Honolulu to rendezvous with SANDS. SANDS to anchor and tether FLIP.
14 August 0800W	CONRAD departed Honolulu to test pneumatic source and to run from 22°N 157°50′W to 55°00′N 157°50′W as a source ship.
0800W	REXBURG departed Pearl Harbor to tow a thermistor chain in the vicinity of the expected water mass boundary between 39°N and 43°N.
0800W	MIKIMIKI departed Honolulu to take velocimeter measurements and BT's along the PARKA track.

b. Anchoring and Data Link Test

12 August	SANDS anchored and tethered FLIP. The radio data link from FLIP to SANDS was tested successfully. PACIFIC APOLLO departed to make oceanographic measurements.

c. Pneumatic Source Test

15 August 1510W	CONRAD tested the Lamont-Doherty Geological Observatory pneumatic sound source near 22°N 157°50′W. (This is approximately 15 nm from the Kaneohe MILS hydrophones and :30 nm from FLIP.) Signals on the MILS hydrophones were too weak to be usable. No signals were observed at FLIP. A decision was made to conduct Phase 1 using fused TNT blocks. The test was concluded at 1619W.

d. Situation at Start

CONRAD	At 22°02′N 157°49′W ready to run to 55°N 157°50′W as a

	source ship, take BT's and bathymetric measurements.
FLIP-SANDS	Anchored and tethered at 27°20.5′N 157°47′W.
PACIFIC APOLLO	At 25°00′N 157°50′W taking deep velocimeter measurements and BT's.
MIKIMIKI	At 27°30′N making velocimeter and BT measurements.
REXBURG	At 32°30′N enroute to water mass boundary.

e. **Acoustic Operations**

15 August 1727W — The first charge of Phase I was exploded at 22°02′N 157°49′W. CONRAD then steamed northward at 10 knots. Fused TNT blocks were used. The shots were alternately at 500 feet and 60 feet on the following schedule:

Minutes After the Hour	Shot Depth
00	500 ft
02	60 ft
05	500 ft
07	60 ft
etc. to	
50	500 ft
52	60 ft

After the 52 minute shot there was a pause until the start of the next hour for ambient noise measurements.

16 August 1752W — The shot sequence was interrupted and the pneumatic sound source rigged on CONRAD.

1930W — Operation of the pneumatic sound source was started. CONRAD was then approximately 30 nm south of FLIP.

17 August 0730W — The pneumatic source was stopped and the shot sequence resumed. CONRAD was then approximately 60 nm north of FLIP. No signals from the source were seen on the Kaneohe MILS phones; apparently signals were strong enough on FLIP to justify this period of operation.

19 August 2037W — The telemetering transmitter on FLIP failed and near the same time the tether between FLIP and SANDS parted. At this time CONRAD was at 38°30′N. In raising anchor to get underway for retethering, SANDS lost her anchor by the parting of the weak section at the bottom of the anchor line.

20 August 1500W — SANDS was reanchored, FLIP was retethered, and the shot sequence was resumed. CONRAD returned to her position at the time of the interruption and resumed steaming north. It had not been possible to repair or replace the telemetry transmitter, so for the rest of Phase 1 and part of Phase 2 data transmission from FLIP to SANDS was by hard wire link (velocimeter cable).

The second anchoring of SANDS was even less successful than the first. The drift rate was excessive and it was assumed that a second anchor had been lost. To retard drift the tether line was doubled and SANDS' bow thruster used. The drift was then acceptable and Phase I was continued to the end.

24 August 2245W	The last shot of Phase 1, Number 4145, was exploded at 55°N.

f. Ship Oceanographic Measurements

A set of graphs in which the latitude of each ship has been plotted against date and time is appended. In all, including Phase 1 and Phase 2 and the time between, 595 oceanographic stations were reported.

g. Aircraft Operations

Aircraft of Patrol Squadron 28, Fleet Air Wing 2 made air drops of expendable aircraft BT's during both Phase 1 and Phase 2 at 25 nm intervals along selected portions of the PARKA I track. A table indicating the time and area covered by each flight is given in Appendix B8 of this Report, along with a complete discussion of the results obtained.

2. Phase 2

a. Preparations

(1) Ship Departures

23 August 1600W	MARYSVILLE departed Pearl Harbor.
26 August 0800W	RADFORD departed Pearl Harbor.

(2) Miscellaneous

PACIFIC APOLLO repositioned FLIP.

SANDS anchored, and retethered to FLIP.

PACIFIC APOLLO then returned to Honolulu for repairs to starboard engine.

b. Situation at Start of Phase 2 (27 August 1400W)

FLIP-SANDS	27°22′N 157°57′W
PACIFIC APOLLO	24°25′N 157°51′W making oceanographic measurements
RADFORD	22°10′N 157°51′W beginning projector tow
MARYS-VILLE	25°04′N 157°50′W making oceanographic measurements
MIKIMIKI	45°53′N 157°49′W making oceanographic measurements
REXBURG	49°48′N 157°44′W towing thermistor chain
TERITU	26°46′N 157°50′W making oceanographic measurements

CONRAD	48°31'N 157°22'W making oceanographic measurements

c. Acoustic Operations

27 August 1400W	Beginning of Phase 2. The projector was turned on at 1400W for the first full 45-minute-on period. Frequency 178 Hz, Level 102 dB//μb at 1 yard. Ship speed 10 knots. The hourly schedule was as follows: 00 min: projector on 45 min: projector off 50 min: MK59, 2500 ft 52 min: MK59, 2500 ft 55 min: 3 lb TNT, 60 ft 57 min: 3 lb TNT, 500 ft 59 min: 3 lb TNT, 500 ft
28 August 0740W and 1140W	First transmissions of PRN signal for NRL tests in preparation for Phase 3. On succeeding days these transmissions were at 0840W and 1240W.
28 August 2100W to 2300W	Interruption in acoustic transmission during transfer of equipment from SANDS to RADFORD.
30 August 0030W	Projector failure.
0300W	SANDS anchor cable parted, also tethering and telemetry lines.
0730W to 0930W	Air drop of parts for SANDS plotter.
1600W	Air-dropped package recovered by SANDS.
2300W	Resumption of acoustic operations, RADFORD at 35°50'N.
2 Sept 0500W	Interruption due to hydrophone troubles on FLIP.
1800W	Resumption of operations, with RADFORD back at 0400W position.
4 Sept 2200W	Interruption due to failure of power amplifier on RADFORD.
5 Sept 0048W	It was decided that the power amplifier could not be repaired, and that PHASE 2 would be completed using explosives only, with the shot sequence (listed above) repeated every 15 minutes.
5 Sept 0530W	End of PHASE 2.

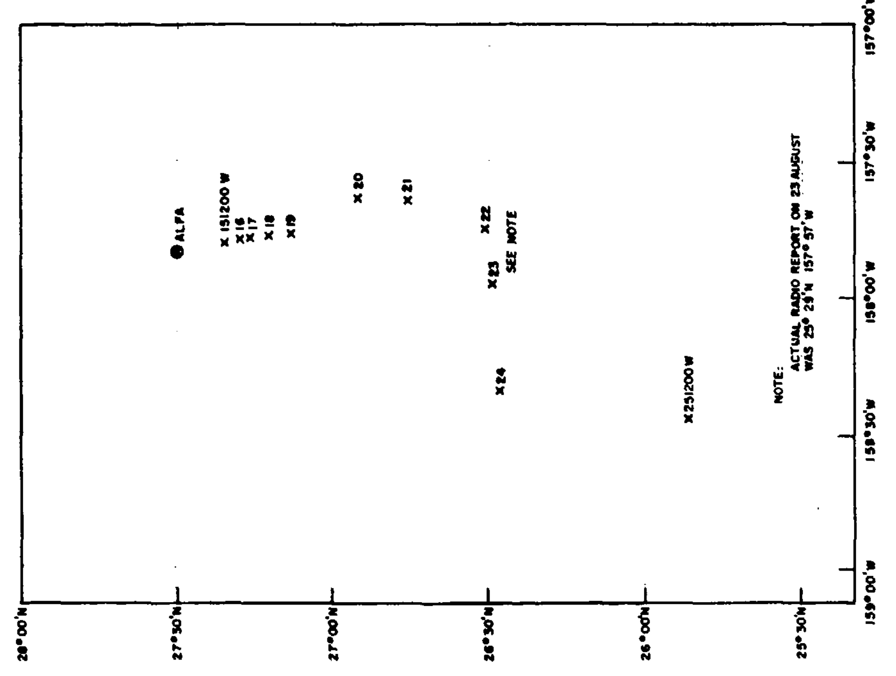

Fig. A-1 – Reported noon positions of USNS SANDS during phase 1 (U)

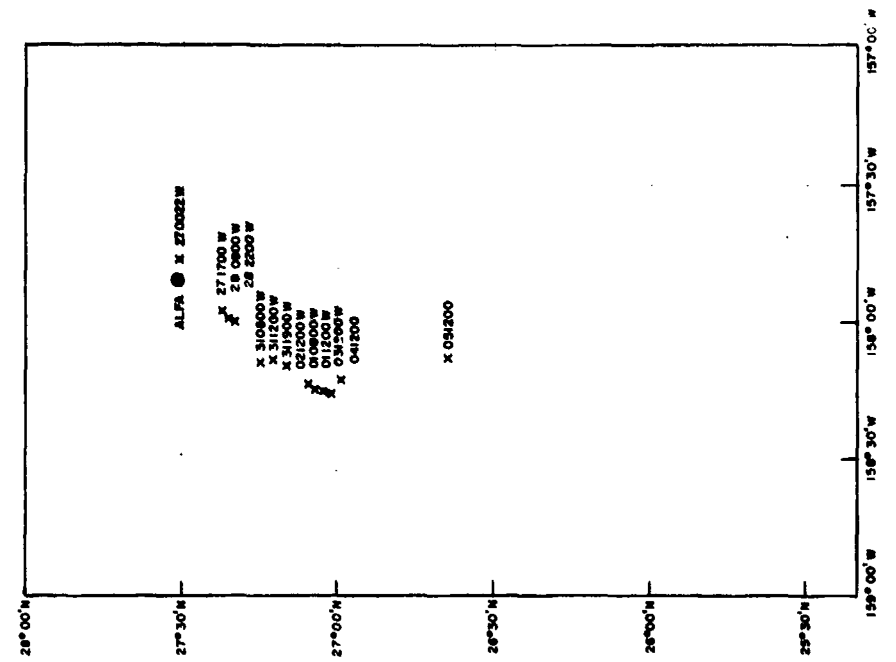

Fig. A-2 – Reported positions of USNS SANDS during phase 2 (U)

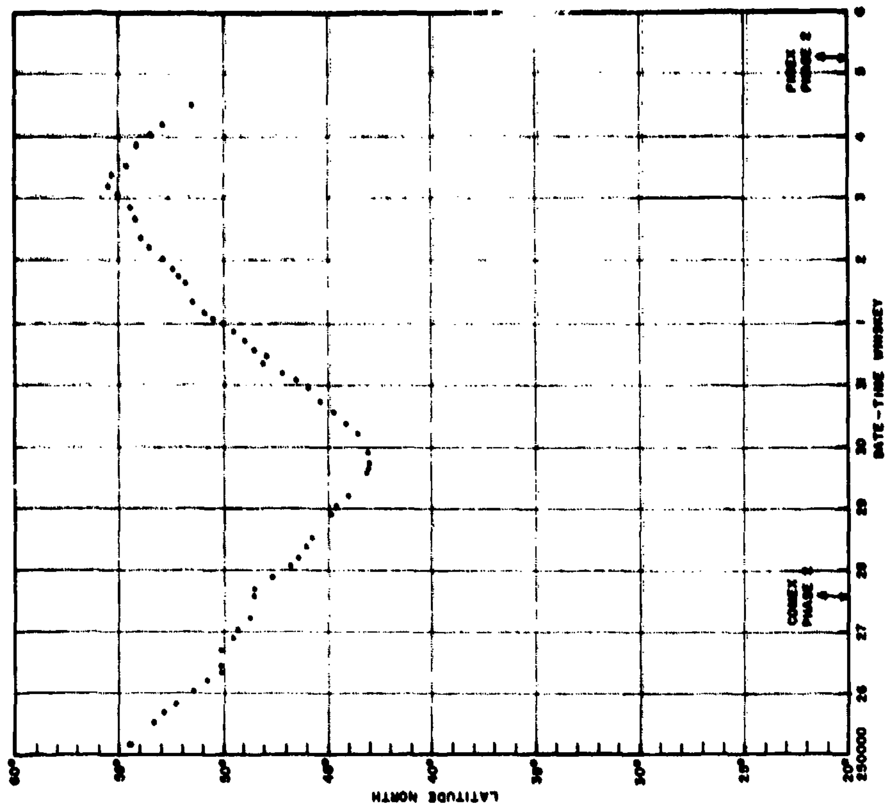

Fig. A-4 — Reported positions of R/V CONRAD during phase 2 (U)

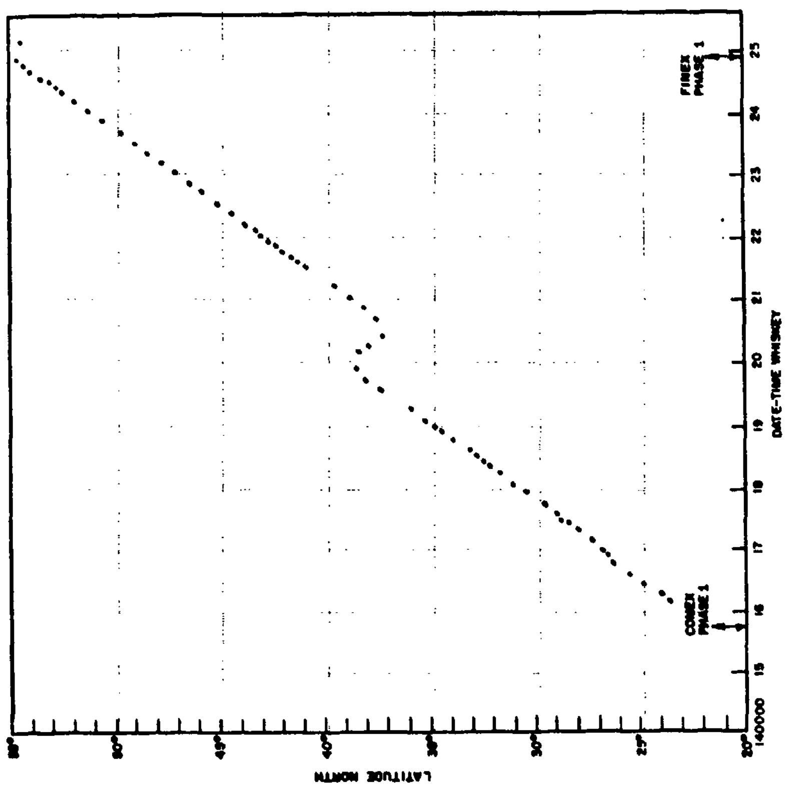

Fig. A-3 — Reported positions of R/V CONRAD during phase 1 (U)

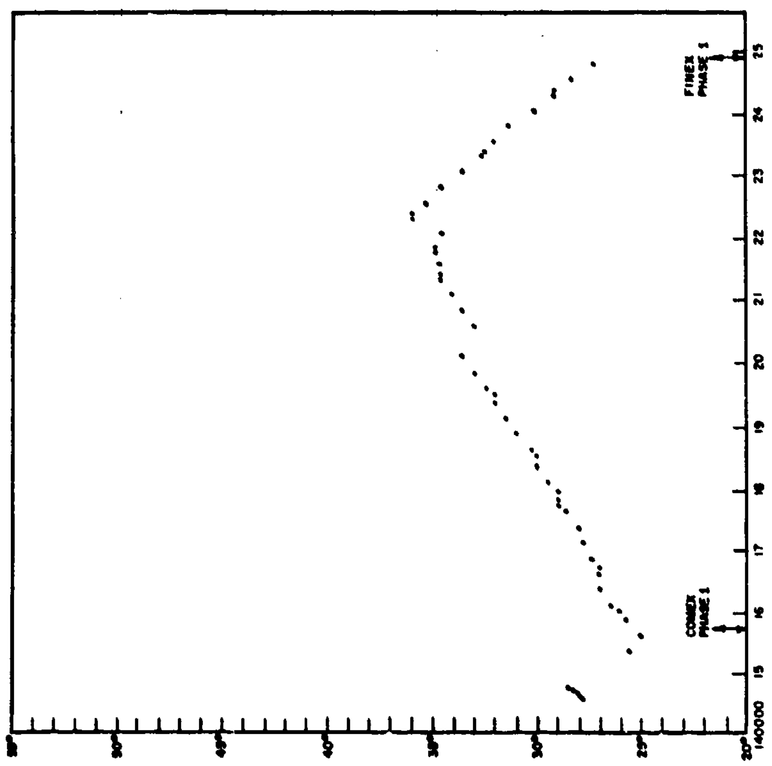

Fig. A-5 – Reported positions of M/V PACIFIC APOLLO during phase 1 (U)

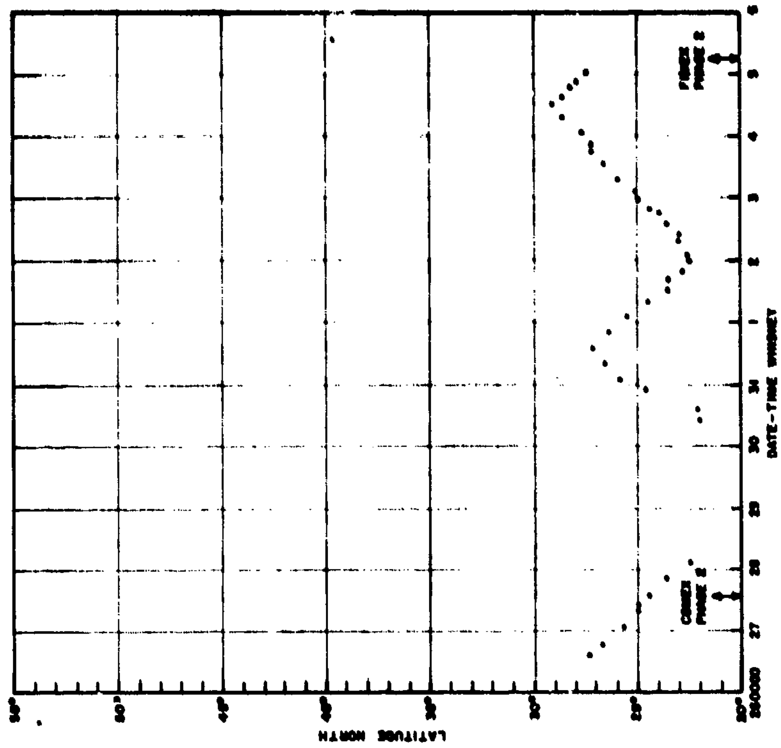

Fig. A-6 – Reported positions of M/V PACIFIC APOLLO during phase 2 (U)

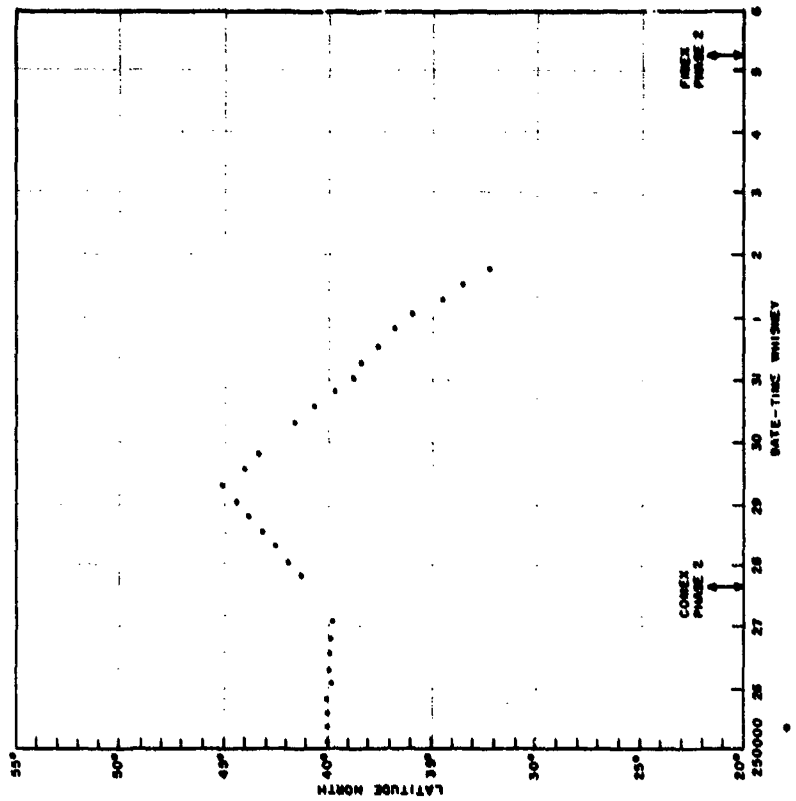

Fig. A-8 — Reported positions of USS REXBURG during phase 2 (U)

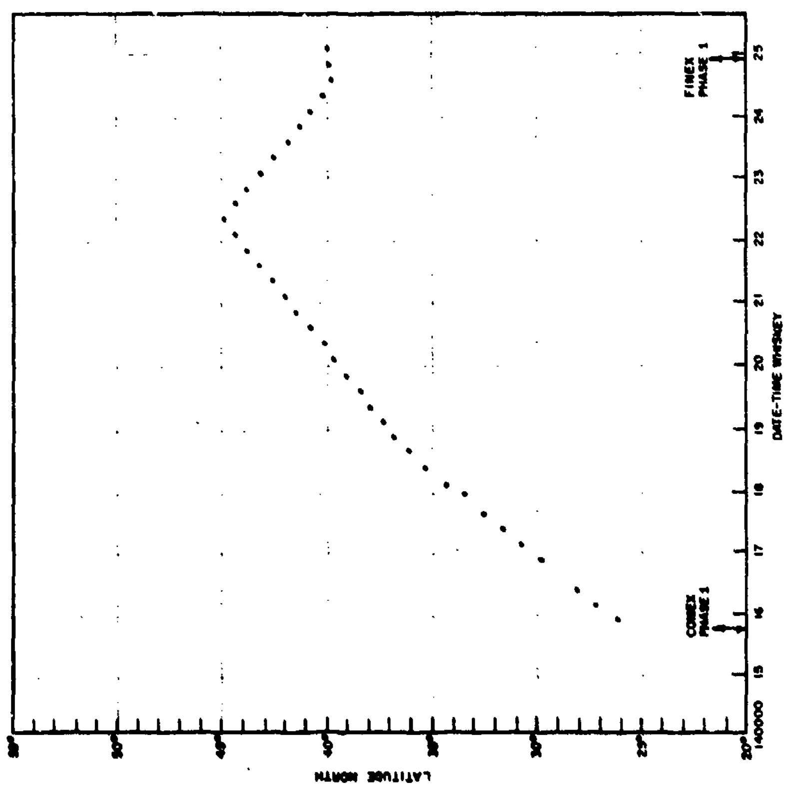

Fig. A-7 — Reported positions of USS REXBURG during phase 1 (U)

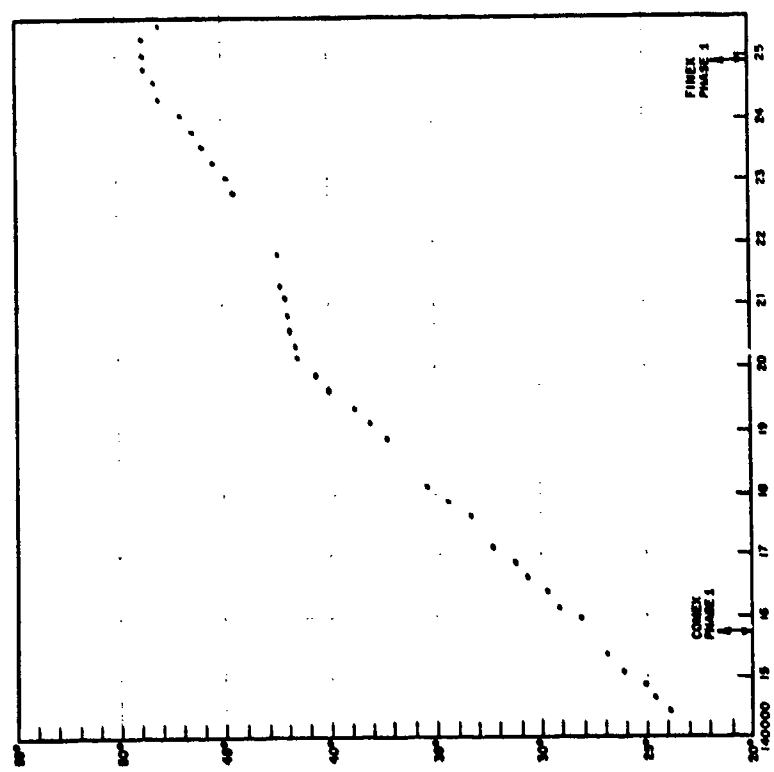

Fig. A-9 — Reported positions of R/V MIKIMIKI during phase 1 (U)

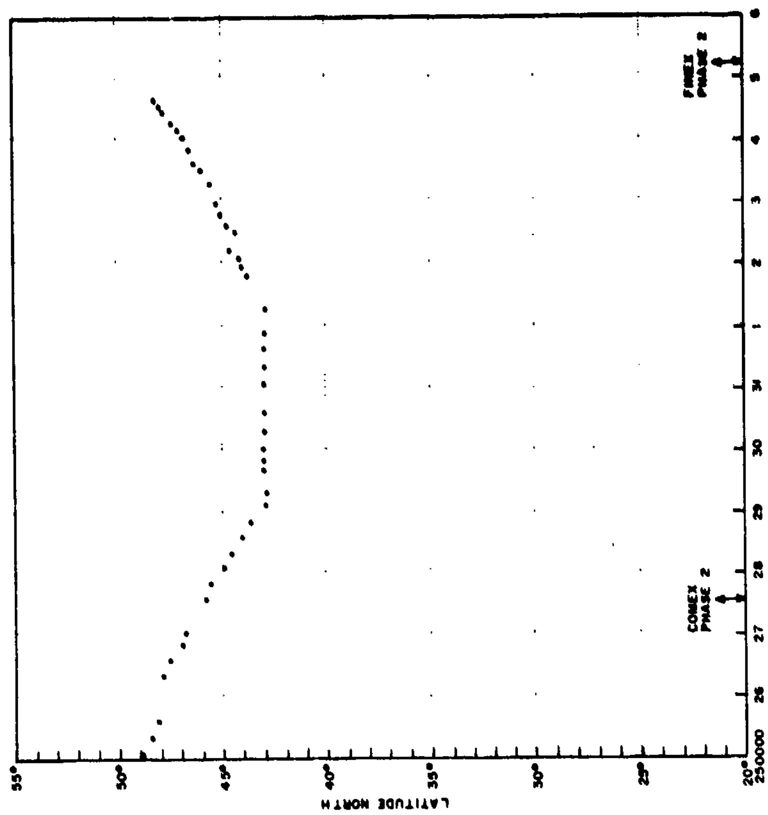

Fig. A-10 — Reported positions of R/V MIKIMIKI during phase 2 (U)

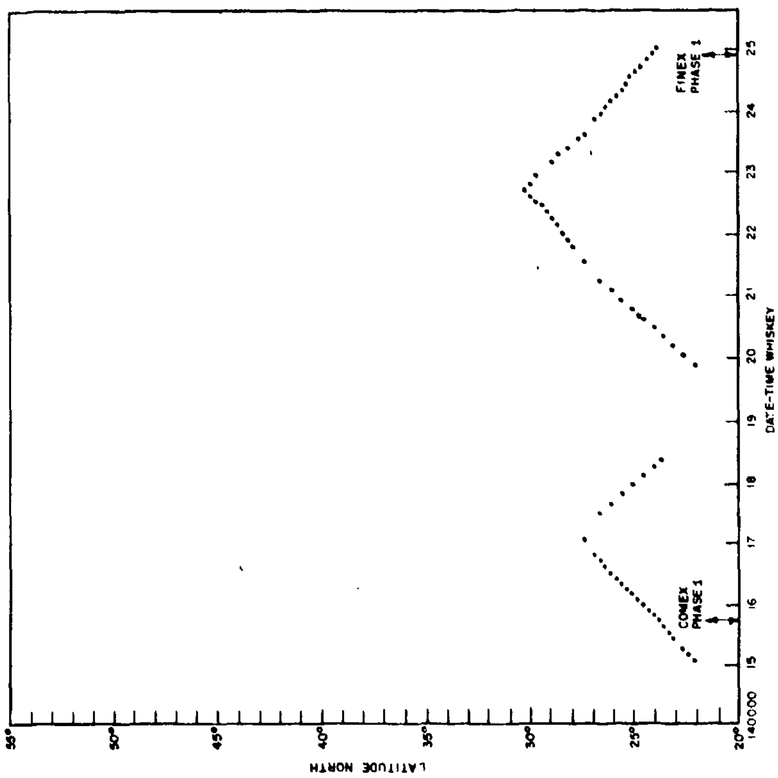

Fig. A-11 — Reported positions of R/V TERITU during phase 1 (U)

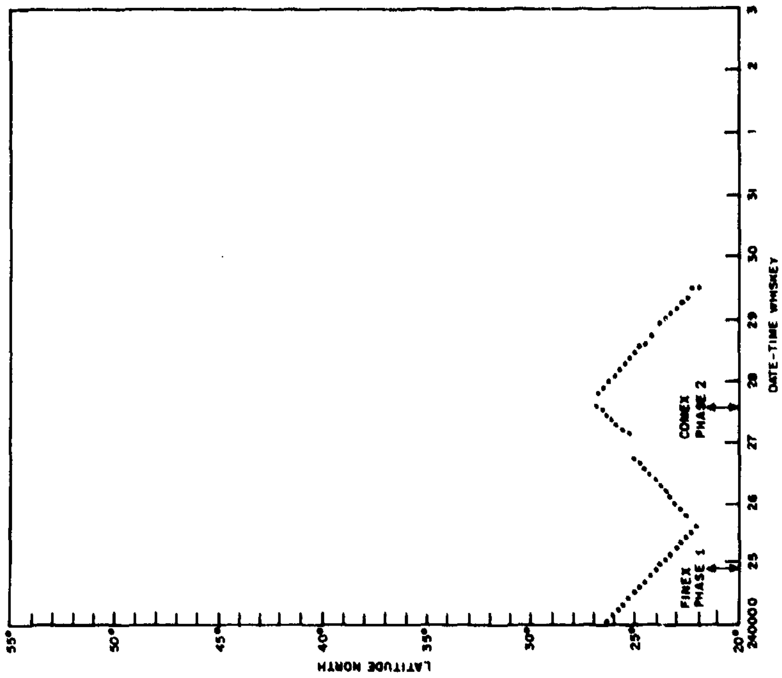

Fig. A-12 — Reported positions of R/V TERITU during phase 2 (U)

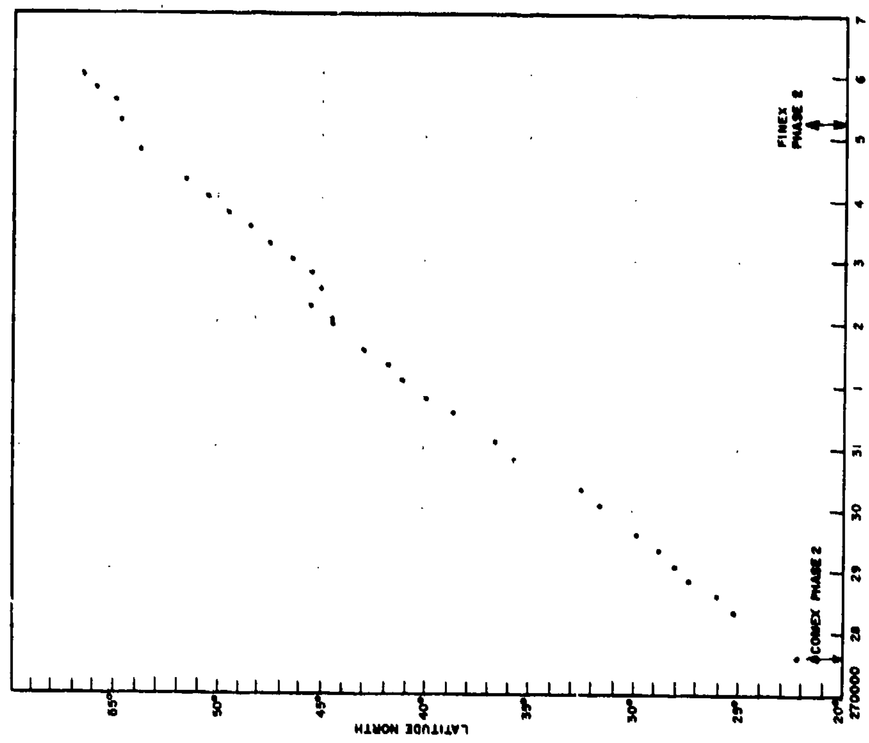

Fig. A-13 – Reported positions of USS RADFORD during phase 2 (U)

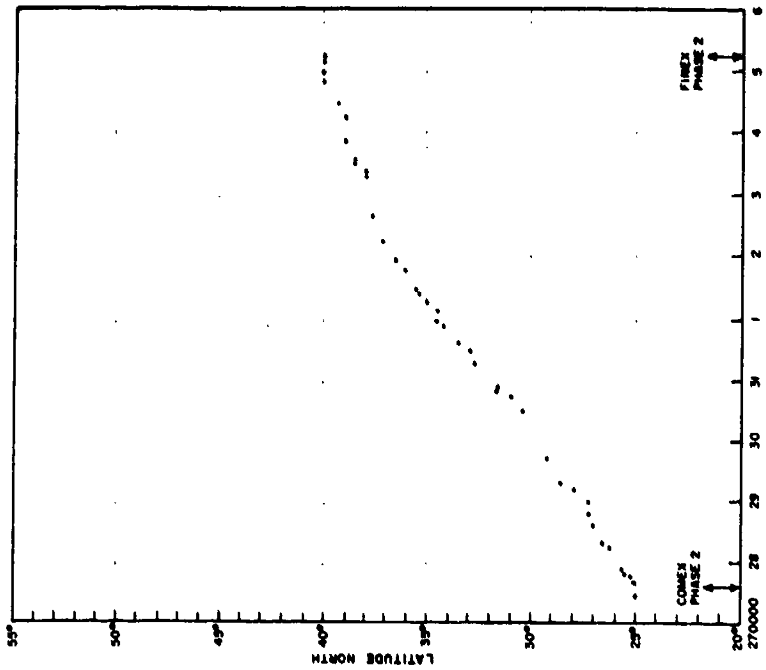

Fig. A-14 – Reported positions of USS MARYSVILLE during phase 2 (U)

Appendix B (U)
ENVIRONMENTAL MEASUREMENTS

This Appendix is divided into 14 sections, each dealing with a particular aspect of the environment in the PARKA I area, or with a particular sampling program.

1. Review

K. W. Lackie
Undersea Surveillance Oceanographic Center
Naval Oceanographic Office

Oceanographic data were collected at regular intervals during each day of the experiment at several key locations: the acoustic source, the receiver, and at one to three points in between. Every ship in the experiment was engaged in the collection of environmental data, including the four primarily occupied with acoustical measurements. The other five ships devoted full time to the collection of oceanographic data. These data comprise measurements of sound velocity or of temperature and salinity as functions of depth to points well below the axis of the permanent sound channel and to the deep ocean bottom in many cases. All ships took Expendable Bathythermograph (XBT) readings of temperature vs. depth to 2500 ft every six hours. Deep data were taken by five of the ships at intervals ranging from six to twenty-four hours. Sampling at a higher rate to observe more rapid variations in the near-surface structure was accomplished by having aircraft drop Aircraft Expendable Bathythermographs (AXBT's) at 25-nm spacings along the acoustic path on alternate days. A NAVOCEANO aircraft made two continuous recordings of sea-surface temperatures along the whole PARKA I track, one on 22-23 August and the other on 28-29 August. Thus, the most complete picture possible of the oceanographic conditions existing in the area was sought, with the emphasis on describing this picture most completely during the period when acoustic energy was being propagated along the track.

A total of about 500 AXBT's was dropped by aircraft in their nine runs along the track. All ships combined dropped a total of nearly 600 XBT's along various portions of the track. A thermistor chain tow produced a continuous temperature profile to 220 meters below the surface, once along the entire track and several other times over selected portions of it. In addition, there were 51 Salinity-Temperature Density (STD) vertical profiles and 99 deep sound velocimeter vertical profiles taken during the PARKA I experiment. Continuous bathymetry and frequent weather and sea state observations were also collected by all ships equipped to do so.

A Scripps-Convair "Monster Buoy" moored at 43°N on the track provided temperature data from the upper 500 meters of water in the

thermal boundary region, transmitting it to FNWC four times a day. Details of its instrumentation are given on page 28.

In designing the oceanographic sampling program, the intent was to acquire much more information than was necessary for a test of the propagation loss model as programmed at present, and this was accomplished. An extensive bank of oceanographic data and associated acoustical information has thus been established, which can be used for further model development. Some representative samples of the environmental data are included in this report.

The Undersea Surveillance Oceanographic Center (USOC) of NAVOCEANO was selected as the focus for all environmental data collected during the experiment. In carrying out this responsibility, USOC personnel instructed shipboard personnel in analysis procedures and transmission formats. During the period of the experiment, two people normally worked at Fleet Weather Central (FWC) Pearl, and one at the Operation Control Center (OCC) Kaneohe.

The major effort at FWC Pearl was in checking and coding incoming data prior to submission to the Fleet Numerical Weather Central (FNWC) computers. In addition, all incoming AXBT and Airborne Radiation Thermometer (ART) aircraft were met in order to permit a short debrief of air crews and a pickup of the temperature traces. Daily data pickups at the Hawaii Institute of Geophysics and frequent coordination trips to the OCC Kaneohe were also made.

Operations at Kaneohe included radio watchstanding, data quality checking, data coding and transmission. After being copied from the radio, data from PARKA ships were checked for errors, then recoded for transmission by teletype to FWC Pearl. During Phases 1 and 2, over 4000 separate data messages were handled at the OCC Kaneohe and FWC Pearl. In nearly all cases, the data were checked and in the system within a few hours. The total data collection is stored on digital tape, as are all the acoustical measurements. Copies of these tapes are available to qualified agencies upon application to the Director, Maury Center, Code 102-OS, Office of Naval Research, Washington, D.C. 20390.

2. Experimental Operations

K. W. Lackie
Undersea Surveillance Oceanographic Center
Naval Oceanographic Office

a. Phase 0

Phase 0 consisted of all PARKA I observations carried out prior to the commencement of acoustic transmissions, and was completed by 5 August. R/V TERITU was the largest contributor to Phase 0, completing a series of STD stations to a depth of 1500 meters between 22°N and 30°N once each month in May, June and July. The entire Phase 0 program of R/V TERITU is discussed below on pages 48 and 49.

In addition, during late July and early August, USS MARYSVILLE made a transit south along the entire PARKA track towing the Naval Undersea Research and Development Center (NURDC) thermistor chain, recording a continuous temperature profile to a depth of 220 meters. Also during this period, R/V CONRAD collected XBT and vertical STD profiles and a bathymetric and seismic reflection profile along the track while enroute to Hawaii from Alaska. The Phase 0 information assisted in determining where to position the environmental data ships during the experiment itself.

b. Phase 1

In order to obtain oceanographic information where it would be most useful; plans called for frequent 750-meter XBT drops from the source ship (CONRAD), particularly in areas where large changes of surface temperature were evident. Although it would have been useful to have data deeper than 750 meters available at the source location, stopping the source ship to collect it was not considered practicable. At the other end of the track, the FLIP/SANDS combination made several deep sound velocimeter measurements to the bottom at their location, in addition to numerous XBT drops. Figure B-1 shows a series of velocity profiles at FLIP's position which were computed from her XBT measurements.

During most of Phase 1, M/V PACIFIC APOLLO collected deep velocimeter data and XBT's several times a day along the southern half of the track, maintaining an average Speed Of Advance (SOA) of five knots. Since the source ship averaged about 10 knots, PACIFIC APOLLO remained approximately half way between the source and the receiver.

R/V MIKIMIKI departed Honolulu several days before CONRAD, and collected one deep velocimeter station and several XBT's every day until she arrived at the water mass boundary at 43°N, where she was overtaken by CONRAD. MIKIMIKI's SOA was reduced to five knots, providing time for several deep stations a day in addition to XBT's. In this manner MIKIMIKI remained about mid-way between CONRAD and the water mass boundary.

In addition, USS REXBURG towed the NURDC thermistor chain along the track from 37° to 45°N, then back to 41°N. This permitted a measurement of the positions of the water mass boundary located in this region.

Independent of other ship movements, TERITU collected STD data to 1500 meters and XBT's between 22° and 30°N during part of Phase 1.

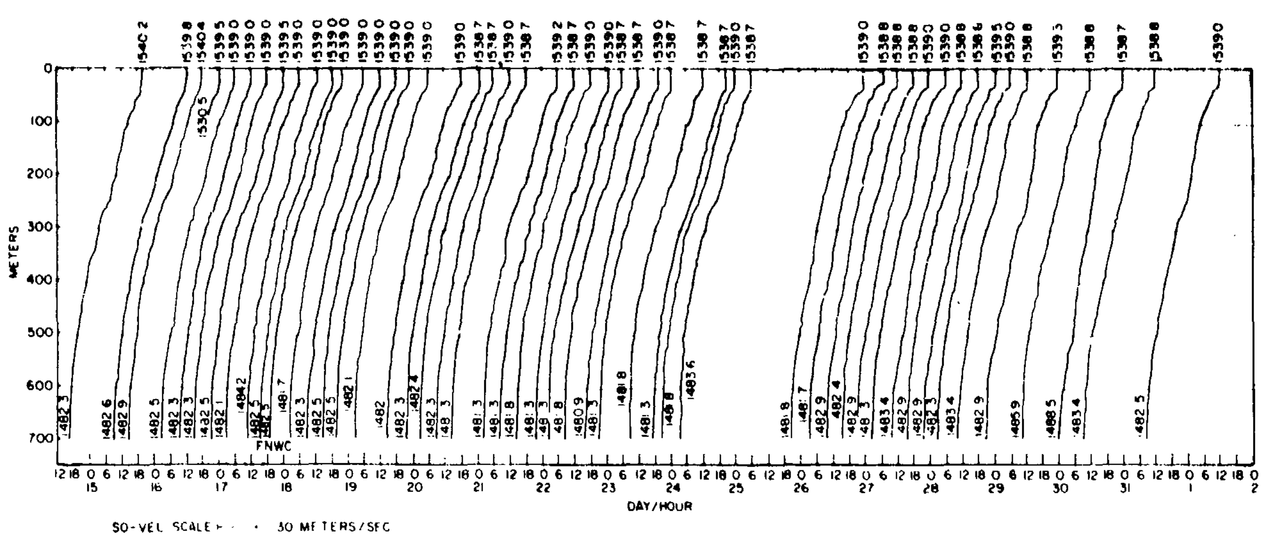

Fig. B-1 – FLIP sound velocimeter time series
14 Aug.-2 Sept. 1968 (U)

c. **Phase 2**

During Phase 2 USS RADFORD acted as source ship, and MARYSVILLE became the environmental data collector along the southern half of the track. MARYSVILLE's schedule was similar to that of PACIFIC APOLLO during Phase 1 – an average speed of five knots so that her position remained roughly halfway between RADFORD and the receiver. During the first half of Phase 2, MIKIMIKI steamed southward and met RADFORD at about 43°N, halfway through the Phase. During the second half of Phase 2, MIKIMIKI repeated her pattern of observations of Phase 1, taking stations at points halfway between the source ship and the water mass boundary at 43°N.

CONRAD also collected local oceanographic data along the northern half of the track and TERITU continued observations between 22°N and 30°N. PACIFIC APOLLO had to return to Honolulu for minor repairs after repositioning FLIP prior to the commencement of Phase 2, but was able to collect several deep vertical sound velocity profiles between 22° and 30°N.

During the first three days of Phase 2, REXBURG drifted to conserve fuel. Just before being reached by RADFORD, REXBURG resumed towing the thermistor chain through the water mass boundary from 41° to 44°30'N, then back south to 43°30'N. At this point, the thermistor chain was retrieved to allow REXBURG to proceed south at greater speed to investigate local conditions nearer to FLIP/SANDS. The thermistor chain tow was resumed from 32°N southward to 24°N giving a good temperature profile to a depth of 220 meters in the region of the large horizontal gradients previously found just north of FLIP/SANDS.

All ships took XBT's every six hours.

d. **Phase 3**

Phase 3 comprised programs of bottom reflectivity and long baseline coherence measurements.

A description of these programs is given below on pages 157-165.

3. Data Quality

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a. Data Transmission

The environmental data from all ships were transmitted as soon as practicable after their collection (generally within a few hours) via radio to Hawaii for forwarding by cable to FNWC Monterey. Here they were to be used in producing updated computations of predictions of acoustic transmission loss along the PARKA I track based on current information. Data from RADFORD, SANDS, MARYSVILLE, and REXBURG were transmitted via normal Navy communications directly to Fleet Weather Central (FWC) Pearl Harbor for relaying by cable into the FNWC computers. Non-Navy ships could not use this data link; they passed their data by voice over the Scientific Radio Net to the Operation Control Center located at the Pacific Missile Range Facility on the Kaneohe Marine Corps Air Station. These included PACIFIC APOLLO, MIKIMIKI, CONRAD, and FLIP. At Kaneohe the information was checked, recoded and sent by teletype to FWC Pearl, where it was checked again by NAVOCEANO and FNWC personnel and programmed into the computers in Monterey via cable. Although more laborious and somewhat slower, this latter method introduced far fewer errors into the data messages than did Navy communications. While the Navy-transmitted messages often exceeded five incorrect or misplaced digits per message, the civilian-relayed data averaged less than one error in every five or six messages. This was apparently due to several factors, including: the inherent superiority of voice communication over CW transmission for passing this type of information, radio operator experience (some Navy operators were better than others), the long route involving several relays taken by some of the Navy messages, and the fact that the civilian scientists operating the radios often recognized errors in an original transmission and corrected them immediately. Although the system of assigning project scientists to around-the-clock radio watch may appear to be somewhat wasteful of talent, it seems to pay off in the long run in operations like these where the immediate quality of the message traffic is highly important.

Data from TERITU were sent by teletype to the Hawaii Institute of Geophysics, and hand carried to FWC Pearl for transmission to FNWC.

b. Data from Ship XBT Systems

All ships involved in the experiment carried XBT systems with 750-meter BT's. On a number of ships there were numerous failures of these XBT's at various depths. The failures can be classified as "obviously bad," perhaps

due to premature XBT wire breakage or electrical leakage, and, "not obviously bad, but shown to be so" by comparison with an independent temperature profile taken simultaneously with a system of known accuracy. For those ships whose XBT records were examined, the "obvious" failure rate was at least ten percent.

The velocimeter aboard MARYSVILLE took temperature data with which MARYSVILLE's XBT data were compared. A discussion of these comparisons is given on pages 95 and 96.

c. Comparison of Data from Different Systems

(1) Three Simultaneous Stations

As mentioned earlier, the number of ships making oceanographic environmental measurements during PARKA I permitted comparison of the data taken by various vessels. Such comparisons can be made among Sound Velocity Profile (SVP) measurements made by MARYSVILLE, PACIFIC APOLLO, and TERITU. On 27 August 1968 PACIFIC APOLLO hove to about one nm from MARYSVILLE and the two ships made simultaneous deep SVP lowerings. These measurements began about 2000 hours at about 24°59′N. Sixteen hours earlier TERITU had begun an STD lowering at 24°57′N. The TERITU temperature and depth data were converted to sound velocity by FNWC using Wilson's equation. Data from an XBT dropped from APOLLO also were converted by FNWC to sound velocity. The four sound velocity profiles are plotted in Figure B-2. The sound velocities noted on the figure in meters per second represent minimum and surface sound velocities. Both the surface and minimum velocities measured by all three ships agree within 0.2 meters per second of each other. This is very good agreement, which indicates that:

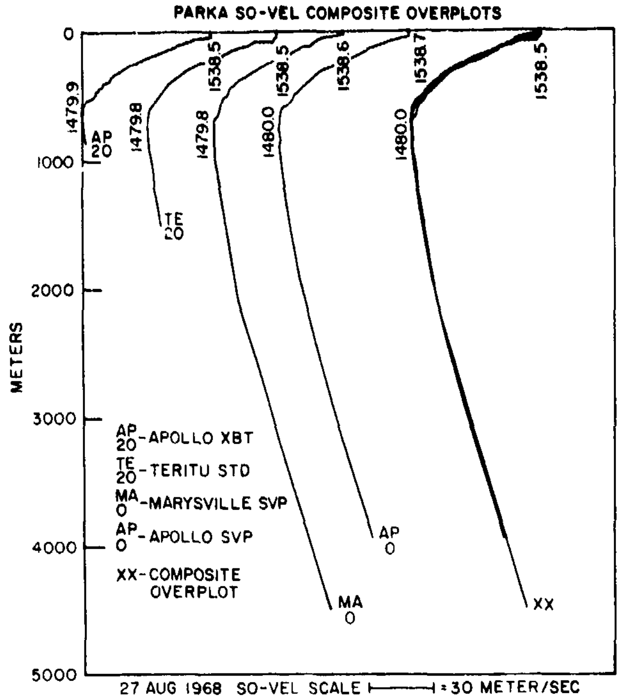

Fig. B-2 – PARKA sound velocimeter composite overplots (U)

The velocimeters aboard APOLLO and MARYSVILLE were in agreement;

The XBT data and TERITU STD data and the FNWC method for converting these data to sound velocity are correct for these particular data points.

Table B-I lists selected data points for the three stations. The agreement is good over most of the points, especially if three factors are kept in mind when comparing the TERITU data with those of either APOLLO or MARYSVILLE. The first is that the measurements were taken sixteen hours apart. For sound velocity values in the first few hundred meters this difference in time could be significant. The second point is that in converting from degrees C (Celsius) and degrees F

Table B-I (U)
Comparison of sound velocities measured from
USS MARYSVILLE, M/V PACIFIC APOLLO, and
R/V TERITU near 24°58'N 157°50'W
on 27 August 1968

Depth (meters)	USS MARYSVILLE Sound Velocity (m/sec)	M/V PACIFIC APOLLO Sound Velocity (m/sec)	R/V TERITU Sound Velocity (m/sec)
0	1538.6	1538.7	1538.5
25	1539.0	1539.1	1538.8
50	1532.4	1537.6	1538.0
75	1527.6	1529.7	1537.7
100	1523.1	1525.8	1526.5
125	1519.6	1521.4	1522.0
150	1517.1	1519.1	1518.0
175	1514.2	1516.3	1515.0
200	1511.2	1513.5	1512.2
300	1497.2	1499.1	1497.8
400	1491.0	1492.6	1489.6
500	1485.6	1486.5	1484.9
600	1480.4	1481.4	1480.5
700	1479.8	1480.3	1479.8
800	1479.9	1480.3	1479.9
900	1480.5	1480.2	1480.4
1000	1481.1	1480.9	1481.5
1100	1481.8	1481.5	1482.3
[illegible]	1482.5	1482.2	1482.8
[illegible]	1483.2	1483.1	1484.0
1400	1483.9	1483.9	1484.7
1500	1484.9	1484.7	1485.7
2000	1490.8	1490.1	
2500	1498.0	1497.4	
30[illegible]	1505.9	1505.4	
3[illegible]	1514.5	1514.0	
[illegible]	1523.6	1523.1	
[illegible]	1531.8		
Minimum Sound Velocity	1479.8 (at 700 meters)	1480.0 (at 766 meters)	1479.9 (at 700 meters)

(Fahrenheit), the FNWC computer program at times introduces a tenth of a degree "rounding off" error into the raw temperature data received at FNWC. This tenth of a degree error in all cases noted is positive. This could result in a sound velocity which is three to five tenths of a meter per second high. The third factor is that in the computation of sound velocity from temperature data, the salinities were assumed. In a test run at FNWC using actual measured values of salinity for a typical TERITU lowering, differences between assumed and measured salinities did cause differences of one or two tenths of a meter per second in a few of the points on the sound velocity profile. The APOLLO and MARYSVILLE data are more directly comparable. It has been seen that the surface and minimum velocities recorded by these two ships were in good agreement; the differences in the sound velocities recorded in Table B-I at various points in the APOLLO and MARYSVILLE data are most certainly due to discrepancies in depth readings between the two instrument packages. In general the agreement among all three profiles is considered good.

(2) Three Deep Stations

Four ships, SANDS, PACIFIC APOLLO, MARYSVILLE, and MIKIMIKI were capable of measuring sound velocity, and the latter two could also measure temperature, to depths of 4000 meters or more below the ocean surface. Each of the four ships made a measurement between 26°15'N and 27°09'N along the PARKA track during late August or early September 1968:

USNS SANDS	20 Aug. 1968	27°08'N
R/V MIKIMIKI	15 Aug. 1968	26°15'N
USS MARYSVILLE	27 Aug. 1968	26°30'N
M/V PACIFIC APOLLO	04 Sept. 1968	27°09'N

Though these measurements were taken over a time period of 20 days and a span of 53 miles, it was found that they may properly be intercompared, since at depths of 2,500, 3,000, and 5,000 meters, the oceanographic environment was shown to change little. For example, Table B-II, showing sound velocity values obtained by SANDS at approximately the same location at different times, indicates the temporal constancy.

The fact that the deep environment remained uniform over this region as well as during this time may be seen from the following PACIFIC APOLLO measurements (sound velocity in meters per second):

Date	Latitude	2500 m	4000 m
17 Aug.	27°02'N	1497.9	1523.2
31 Aug.	26°33'N	1497.8	1523.3
01 Sept.	27°12'N	1497.7	1523.2
03 Sept.	26°00'N	1497.5	1523.2
04 Sept.	27°09'N	1497.9	1523.3

(The values listed for 4000 meters were extrapolated from depths varying between 3813 and 3951 meters using a gradient of 1.7 meters per second per 100 meters of depth.)

From these results, it appears safe to intercompare measurements made by different systems. The measurements made by three of the four ships in this region during the experiment are summarized in Table B-III. Measured velocities were obtained with a velocimeter, and computed velocities were calculated by FNWC using measured temperatures and archival salinities. SANDS data are not included here because of the discovery after the

Table B-II (U)
Comparison of deep sound velocity data
collected by USNS SANDS

Date	Latitude	2500 m	3000 m	3500 m	4000 m	4500 m	5000 m
18 Aug.	27°15'N	1496.1*	1503.3	1511.1	1519.2	1527.5	1536.1
20 Aug.	27°18'N	1496.1	1503.4	1511.0	1519.2	1527.6	1536.2
04 Sept.	27°01'N	1495.6	1503.0	1510.8	1519.0		

*All values are in meters per second.

Table B-III (U)
Comparison of measured versus computed deep sound velocities from PARKA I

Ship and Method	Sound Velocity (m/sec)
2500 Meter Depth	
FNWC predicted	1498.6
PACIFIC APOLLO measured	1497.9
MARYSVILLE measured	1498.2
MARYSVILLE computed	1498.4
MIKIMIKI measured	1498.0
MIKIMIKI computed	1498.8
3000 Meter Depth	
FNWC predicted	none made
PACIFIC APOLLO measured	1505.8
MARYSVILLE measured	1506.1
MARYSVILLE computed	1506.2
MIKIMIKI measured	1506.0
MIKIMIKI computed	1506.6
5000 Meter Depth	
FNWC predicted	1541.4
PACIFIC APOLLO measured	none
MARYSVILLE measured	1541.4*
MARYSVILLE computed	1541.5*
MIKIMIKI measured	none
MIKIMIKI computed	1541.6†

*Extrapolated from 4948 meters on the basis of 1.8 meters per second per one hundred meters.
†Extrapolated from 4900 meters on the basis of 1.8 meters per second per one hundred meters.

experiment of a systematic error in her velocimeter readings, cause unknown. A similar error appeared in MIKIMIKI's measured data, and was found to be due to a systematic error in the depth meter readings, for which corrections have subsequently been applied. The values predicted by FNWC are also included in the table for comparison.

These results indicate good agreement among measurements made with the different instruments. More particularly, they point up the good agreement between FNWC predicted sound velocities and the measured values.

d. Conclusions

The experiment demonstrated that oceanographic data densities can be achieved which exceed our present ability to utilize them acoustically. Furthermore, real-time, on-line acquisition, transmission, and processing of such quantities of data are feasible.

It demonstrated also that good general agreement between predicted and measured values can be attained. For example, FNWC's estimates of salinity based on archival data, when combined with a series of measured temperatures, produced a computed sound velocity trace which fell within ±0.3 m/sec of the mean of comparable measured sound velocities at a depth of 2500 meters. In addition, FNWC produced a series of predicted sound velocity profiles based entirely on archival Nansen cast data which fell within ±0.4 m/sec of the mean measured value at 2500 meters, and was closer at greater depths. A series of comparative plots of predicted and measured profiles is shown in Figures B-3 through B-7. While there are small differences in the main thermocline, they are probably not important acoustically, on the average.

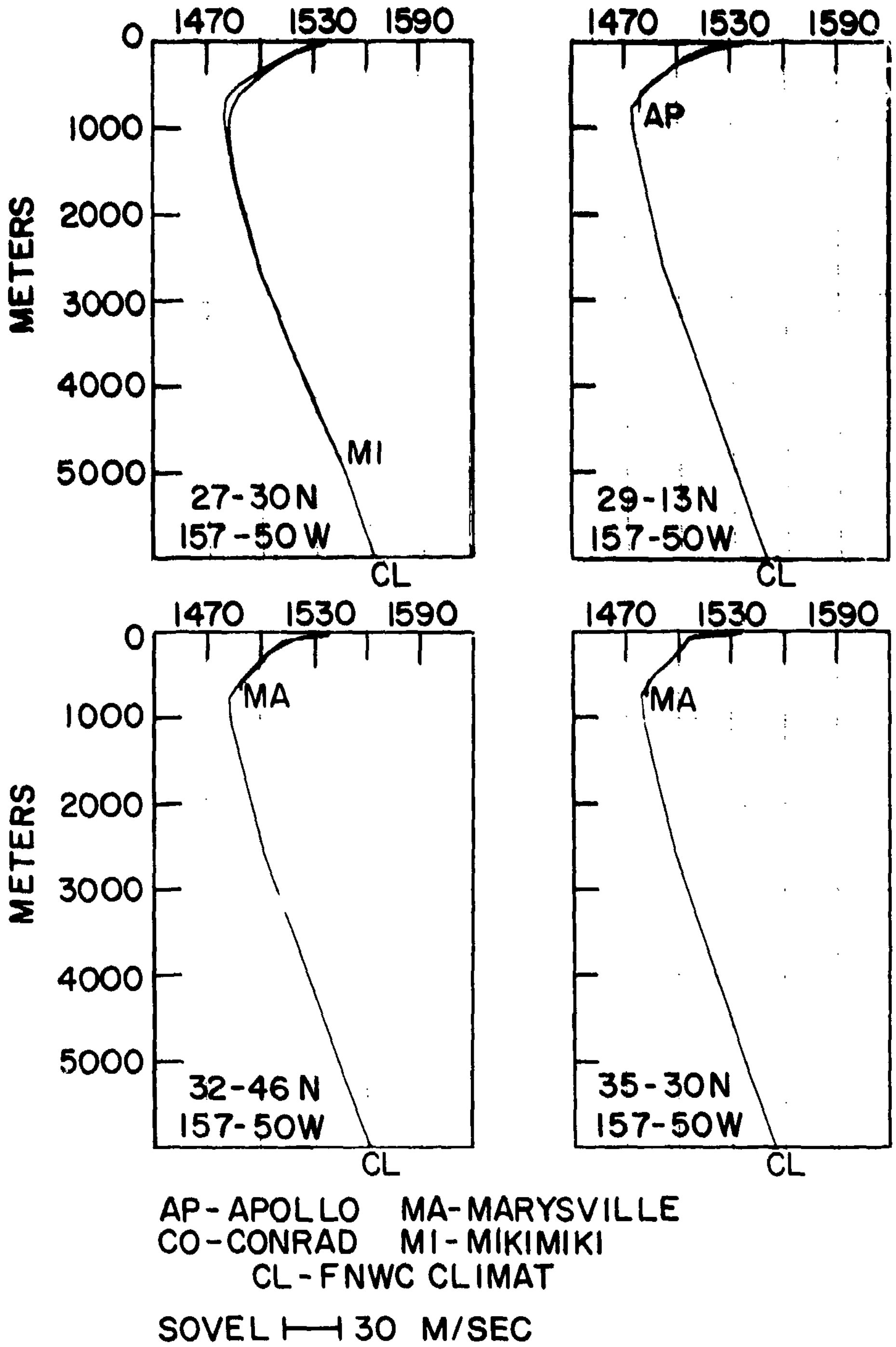

Fig. B-3 – Comparison of FNWC PARKA climatology sound velocities to observed sound velocities (U)

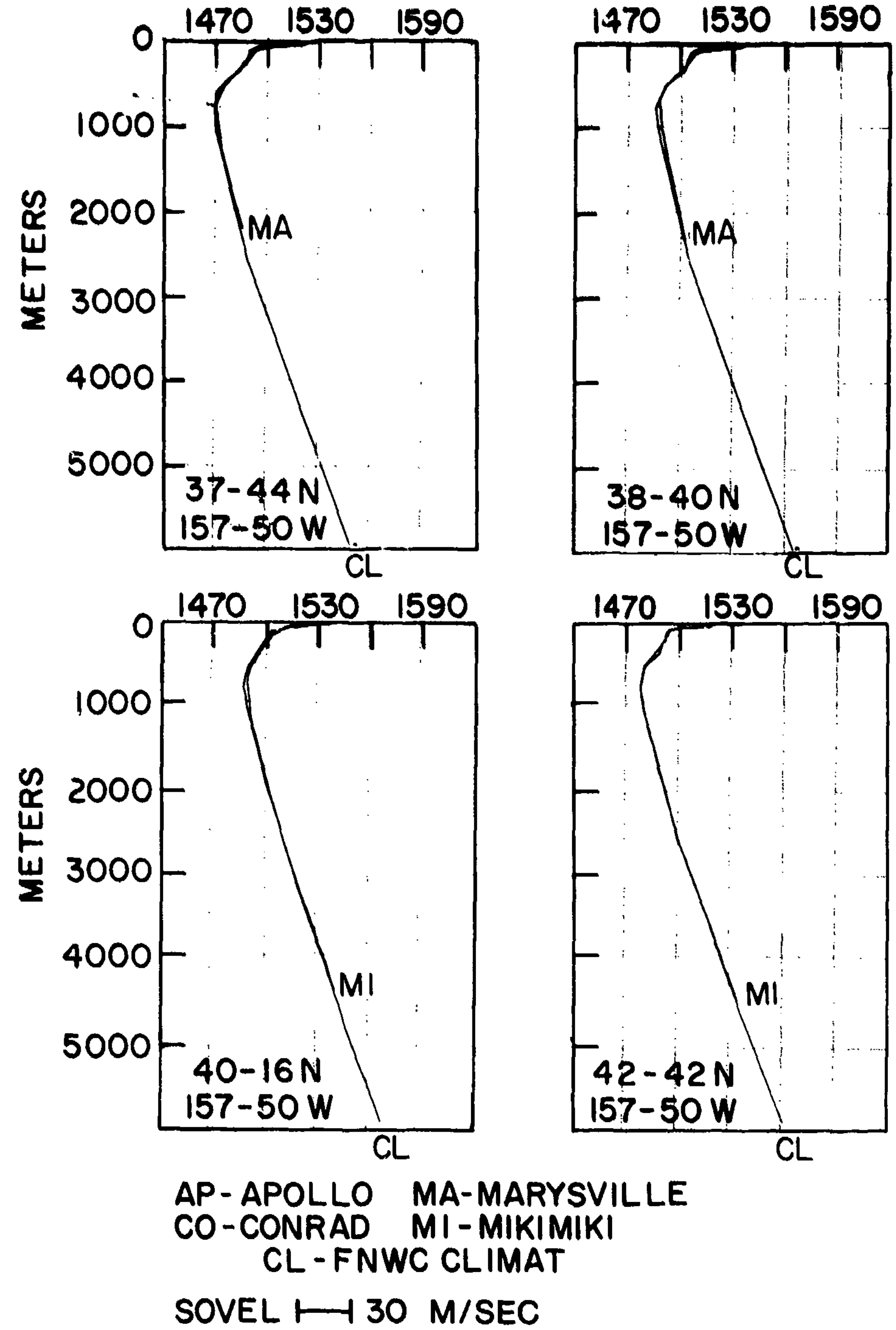

Fig. B-4 – Comparison of FNWC PARKA climatology sound velocities to observed sound velocities (U)

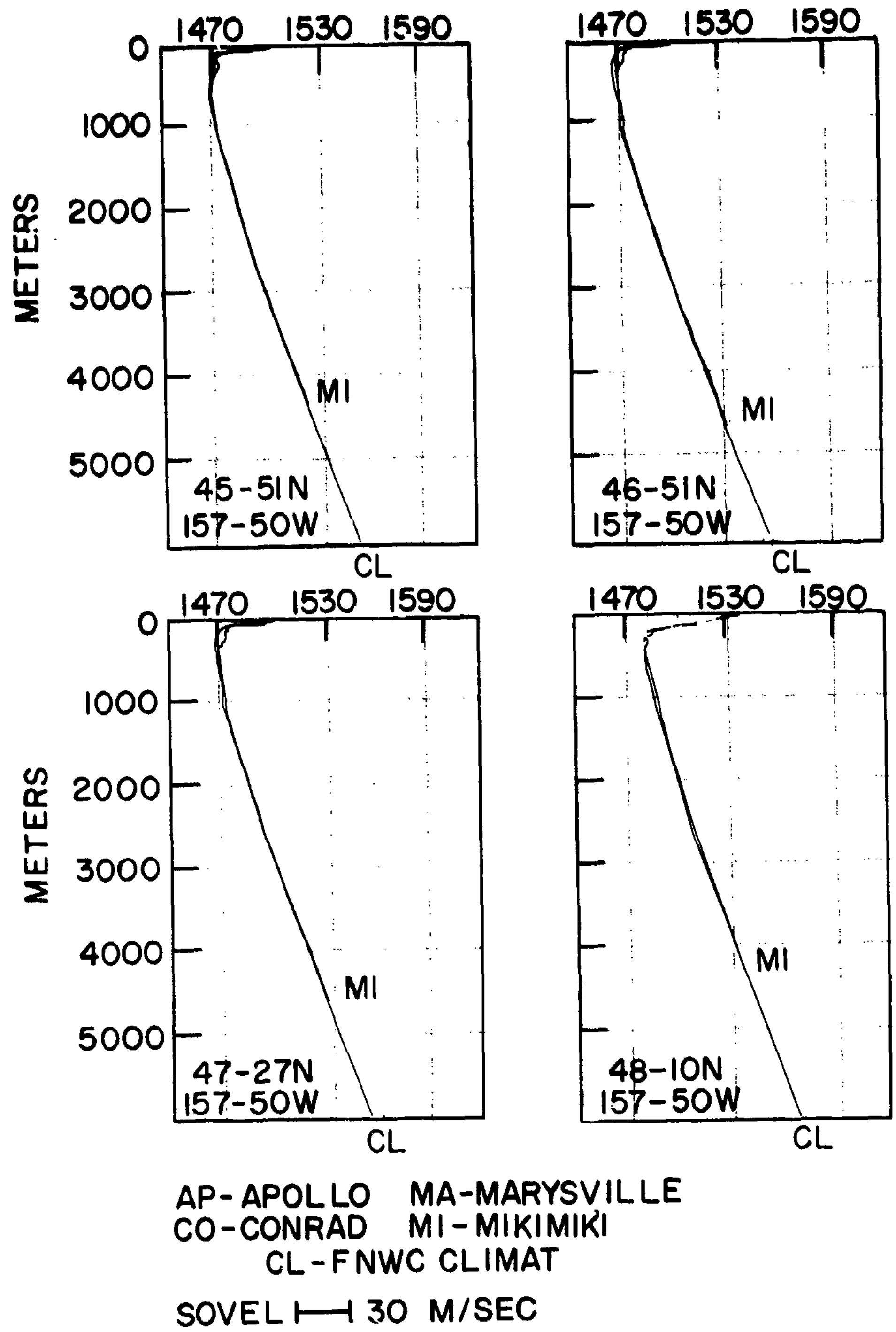

Fig. B-5 – Comparison of FNWC PARKA climatology sound velocities to observed sound velocities (U)

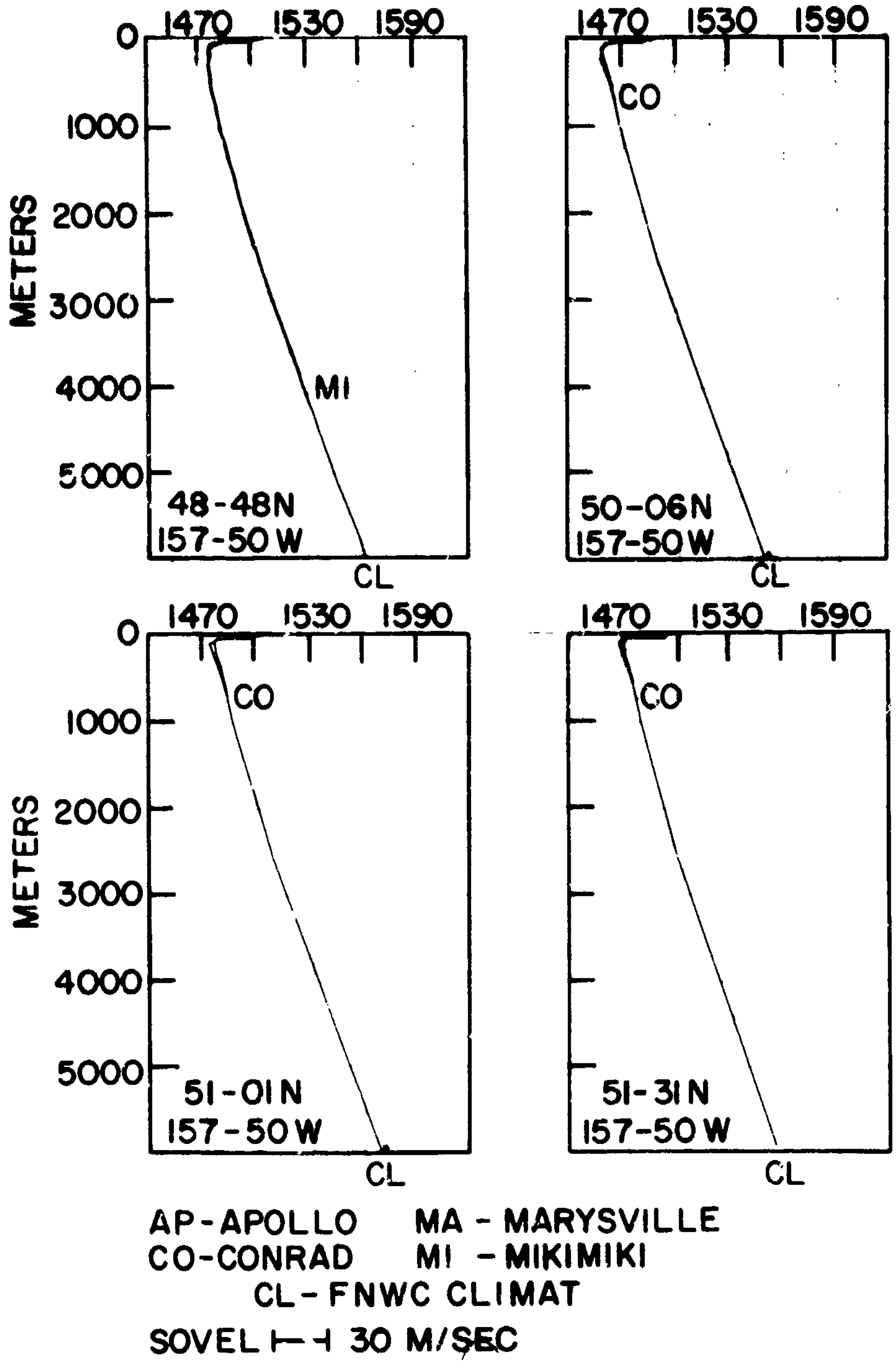

Fig. B-6 — Comparison of FNWC PARKA climatology sound velocities to observed sound velocities (U)

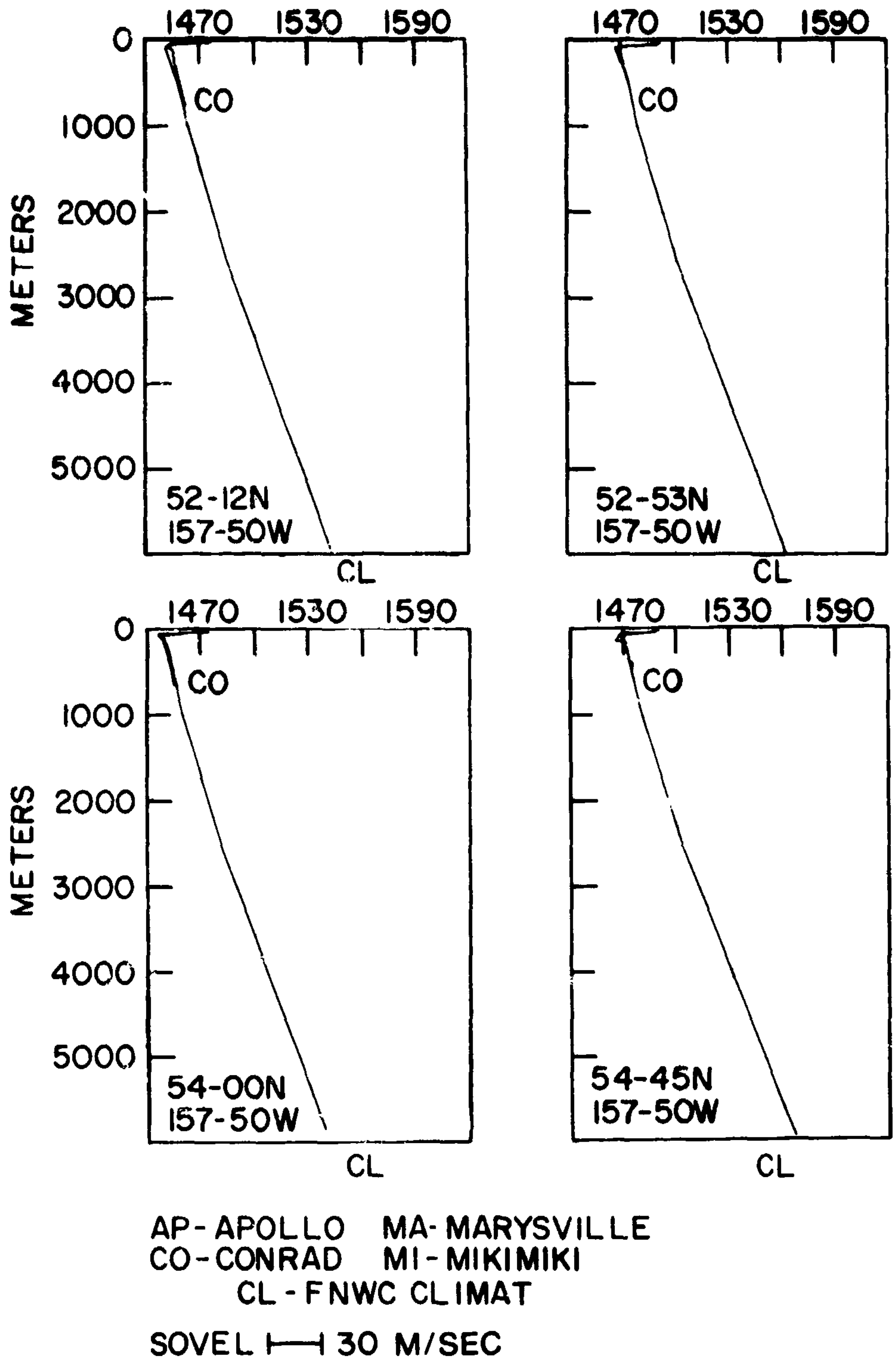

Fig. B-7 – Comparison of FNWC PARKA climatology sound velocities to observed sound velocities (U)

Comparisons of the different sound velocity measuring systems used in the PARKA I experiment show very good agreement among the different methods, with the exception of the MIKIMIKI velocimeter and some of the SANDS velocimeter stations. (This latter problem on MIKIMIKI has been identified as an error in depth meter calibration, and the data have been corrected.) Data obtained with the various systems were highly repeatable, and displayed a maximum deviation from the mean of ±0.3 m/sec at 2500 meters and ±0.5 m/sec at 1500 meters, on those occasions when different ships occupied deep stations within about 60 nm of each other. One solution to reliability of velocimeter performance may be a system of at-sea calibrations; a second, more expensive, but more reliable solution is to employ an inverted echo sounder to determine exact sensor depth. In any event, if depth measurements are open to question, temperature or temperature and salinity measurements will allow retrieval of some velocity information.

The combination of ships and aircraft used provided successful monitoring of a large area, and single aircraft flights quickly revealed major acoustically-related features over a long track. However, it was found that the shipborne XBT's may suffer an undesirable failure rate, and should be checked at every opportunity against systems known to be reliable. For example, a study of 50 XBT's dropped by MARYSVILLE indicated that about 10% had immediately obvious failures; 30% to 50% would be considered "unsatisfactory for oceanographic research purposes" at various depths down to their maximum depth (see pages 95 and 96). Figures on reliability and accuracy of the AXBT's were not obtained.

The ocean environment at depths greater than 2500 meters sampled by the PARKA ships was constant both in time and distance. The measurements of CONRAD (STD) and PACIFIC APOLLO (SVP) from 24°N to 48°N show that the velocity profile at depths below 2500 meters was constant to within 0.2 m/sec in all the measurements.

4. Weather Observations

Captain P. M. Wolff
Fleet Numerical Weather Central

During the month of August, the region south of 40°N along the PARKA I track was dominated by an east-west ridge of high pressure, with the axis located near 37°N. Light and variable winds with scattered cloud cover extended from 30°N to 40°N. South of 30°N, easterly winds of 12 to 22 knots and scattered to variable broken cloud cover prevailed. Early in September, the ridge drifted south and became broad and flat. This resulted in light and variable winds extending from near 20°N to 40°N, with scattered to broken cloud cover prevailing over most of the area. Significant wave heights throughout the period south of 40°N were generally less than three feet.

The surface weather along the PARKA I track, in the region north of 40°N, was characterized by frequent passage of low pressure centers. The period commenced with a low cell in the Gulf of Alaska, resulting in winds from north to northwest of 30 to 40 knots and broken cloud cover. Low pressure centers crossed the track near 50°N on 20 August, 25 August, 27 August, 29 August, 3 September, 12 September, and 15 September. These centers were preceded by southerly winds of 20 to 35 knots with cloudy skies and frequent rain and showers. As each low center crossed the PARKA I track, the winds shifted to north to northwest at 20 to 35 knots with partly cloudy skies.

Significant wave heights in the region north of 40°N were generally from 3 to 6 feet except as noted below.

Date	Height in Feet		Area of Track		
15-17 Aug.	12 to 15		45°N to 52°N		
20 Aug.	6 to 9		47°	55°	
21-22 Aug.	9	12	47°	55°	
25-26 Aug.	9	12	45°	50°	
27-30 Aug.	6	9	40°	56°	except,
(28 Aug.	12	18	44°	54°)	
31 Aug.-01 Sept.	6	9	35°	50°	
03 Sept.	6	9	40°	50°	
06-07 Sept.	6	9	47°	55°	
10-11 Sept.	6	9	45°	55°	except,
(10-11 Sept.	12	15	47°	53°)	
12-15 Sept.	9	12	40°	55°	except,
(13-14 Sept.	12	15	42°	50°)	

Since the current long range propagation model does not make use of sea state data, but assumes that the surface is flat, no use of these data was made in the calculations of transmission loss in this report. They are available, however, for future use or for others who may wish to include a surface reflectivity term other than unity in their analysis of the results.

5. The Scripps-Convair Oceanographic Buoy

R. A. Schwartzlose
Scripps Institution of Oceanography

Under the North Pacific Study program of Scripps Institution of Oceanography, a Convair "Monster Buoy" was moored at 43°N at the center of the water mass boundary region. To accommodate the PARKA I experiment, SIO placed the buoy directly on the PARKA I track at 157°50'W. The buoy provided the following information during the course of the experiment:

Parameter	Height Above (+) or Depth Below (−) the Water (meters)	
Wind speed (5 min avg)	5–10–15	+
Wind direction (5 min avg)	5–10–15	+
Air temperature	5–10–15	+
Dew point (hygroscopic)	5–10–15	+
Dew point (cooled mirror)	15	+
Rainfall	15	+
Solar radiation (1 hr avg)	15	+
Barometric pressure	5	+
Compass heading	5	+
Pitch	0	
Roll	0	
Heave	0	
Mooring load	0	
Surface current speed (5 min avg)	1	−
Surface current direction (5 min avg)	1	−
Water temperatures	1–5–7½–10–12½–15–20–25–30–35–40–45	−
Water temperature, Pressure, Conductivity	50–75–100–125–150–200–250–300–400–500	−

Four times a day at 0000, 0600, 1200, 1800 GMT the meteorological and subsurface data were telemetered to SIO then transmitted to the FNWC, Monterey, California. All data collected from the buoy were also available daily at SIO and ONR (Washington) on a teletype printout.

6. Sea Surface Temperature

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Fleet Numerical Weather Central
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a. General

Sea Surface Temperatures (SST's) were obtained during PARKA I by at least five techniques, three from ships and two from aircraft. The methods used for taking SST's from ships included XBT's, STD or SVP systems, and the standard bucket or injection thermometer. The airborne systems were AXBT's and ART.

All PARKA ships were required to take SST measurements every two hours when possible, in accordance with standard Navy procedures. However, due to the heavy load of message traffic, these were not reported in "real time," unless they were a part of an XBT or deep cast. Instead, they were turned in to FNWC at the end of the experiment, where they (and any non-PARKA measurements in the area) were incorporated into FNWC's files and helped to form the basis for their hemispheric SST analysis.

The ART and AXBT data, on the other hand, were not included in this analysis until later, thus permitting a comparison of the various measurement techniques. Figure B-8 depicts three of these comparisons. The top two graphs compare the data received by ART and AXBT flights on each of two different days. The bottom graph is a comparison of the two ART flights, a week apart, utilized in the top two graphs. In addition, FNWC's hemispheric sea surface temperature analysis based on all other data is included in each graph. Because of the nature of FNWC's computer program, SST's are normally reported in Fahrenheit.

Because of the features depicted, discussion of the graphs is by ocean area. Additionally, the AXBT presentation in the upper two graphs must be corrected to its mean to eliminate the large short-term space variations since they seem to be indicative of instrument calibration error (constant off-set).

b. Upper Graph: 22-23 August

From 22°N, both the ART and corrected AXBT plots show little water mass variation. There is no significant short or long-term space scale variation. From 29°N to 41°N, the corrected AXBT plots indicate no significant variations, but the ART plot shows small-scale variation. The ART has short-term space variations which have a characteristic wave length of approximately 55 miles and an amplitude of 1°F. The ocean front at 40°N is clearly shown by both ART and AXBT plots. The ART instrument was inoperative from 41°N to 48°N. From 48°N to Alaska, short-term space variations are again present although with smaller wave length and amplitude. The 2-3°F variation at 49°N on the ART flight is caused by a reversal in course and change in track of the recording aircraft. Along the entire track the ART plot is uniformly 2°F lower than the AXBT plot. FNWC's sea surface temperature analysis shows good general agreement with both instruments except when approaching the ocean

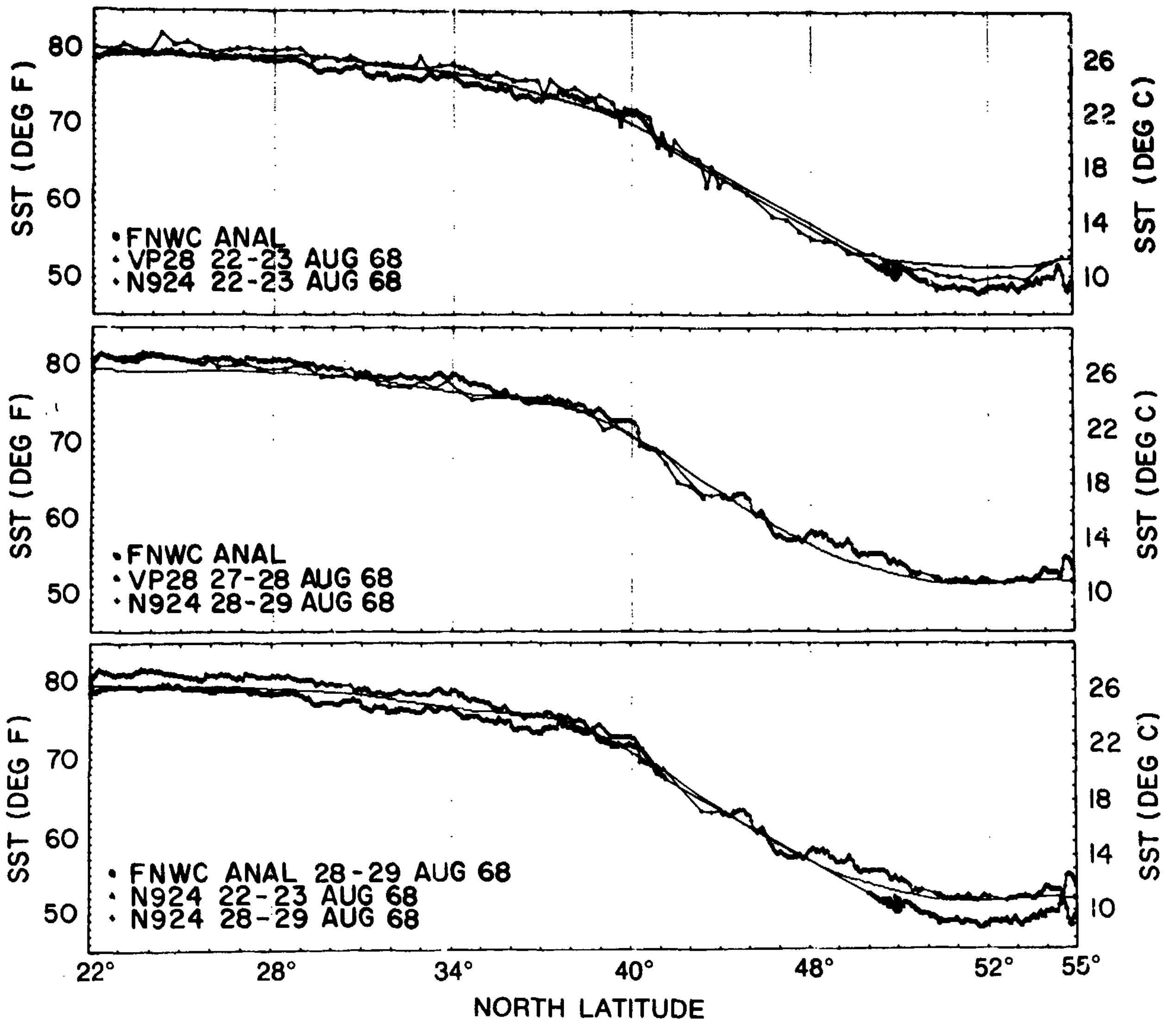

Fig. B-8 — Sea surface temperature vs latitude (U)

front at 40°N and at the northern end of the track. This difference at the northern end of the track is not surprising since there was a paucity of oceanographic data in that area upon which to base an analysis prior to the ART/AXBT flights.

c. **Middle Graph: 27-28 and 28-29 August**

From 22°N to the ocean frontal area at 40°N, the AXBT and ART correspond well. The ART has short-term space variations which have shorter wave lengths and smaller amplitudes than on the upper graph. The ocean front at 40°20′N is strongly marked by a drop of nearly 4°F over a ten-mile range in the ART plot, while not so clearly defined in the AXBT plot, which has a spacing of 25 nm between points. From 43°N to Alaska, the ART plot shows small-scale variations with a wave length of 60 miles and average amplitude of 2°F. The AXBT flight terminated at 43°N,

so no comparison can be made in this area. FNWC's sea surface temperature analysis seems to be 2°F low from 22°N to 26°N, but responded well to the inclusion of earlier ART/AXBT data from 22-23 August in the analysis in the north portion of the piot.

d. Bottom Graph: Comparison Between the Two Sets of Data

The bottom graph shows the results of the ART flights from the top and center graphs for comparison. The latter flight, made seven days after the 22-23 August flight, recorded temperatures along the entire track that are approximately 3°F warmer than the first flight during a period when little change would be expected. Sea surface temperatures recorded by PARKA ships at corresponding latitudes during this seven-day period show little or no change. The FNWC heat exchange analysis showed a positive heat exchange which would cause a maximum increase of 0.3°F, clearly not enough to support the marked temperature difference depicted. This apparent sharp three-degree increase during the week in question was probably not real; it may have been due to incorrect calibration of the ART.

7. NURDC Oceanographic Operations

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a. Operations

(1) General

NURDC operational procedures were generally the same for all phases of the PARKA I Experiment. The thermistor chain was towed at six knots in the assigned operation areas for each phase. Temperature as a function of depth and latitude was recorded continuously while the chain was under tow. BT messages derived from the thermistor chain were logged every hour and every sixth message was transmitted to FWC, Pearl Harbor. The remaining hourly messages were handed to FWC upon arrival in Pearl Harbor. While in transit between operating areas XBT drops were made and messages sent to FWC Pearl Harbor every six hours. BT messages were transmitted to FWC at 0000Z, 0600Z, 1200Z, and 1800Z. Surface temperature measurements were made every other hour on the odd hour throughout Phases 1 and 2. The surface temperature recordings were handed to FWC at the conclusion of Phase 2. All times are local unless otherwise stated. Navigation was by means of Loran A and celestial observations.

(2) Phase 0

NURDC operations were conducted from USS MARYSVILLE (PCER 857) during PARKA Phase 0. Towing operations began at 2200W, 22 July 1968 at 54°25'N, proceeded

south along 157°50'W, and ended at 1800, 5 August 1968 at 22°N. Temperature as a function of depth, and bathymetry were recorded continuously throughout the Phase 0 operation.

(3) Ship Change

During PARKA Phases 1 and 2, operations were conducted from USS REXBURG (PCER 855). The thermistor chain and auxiliary recording and data analysis equipment were transferred from MARYSVILLE to REXBURG in Pearl Harbor during the period of 6-13 August. MARYSVILLE then became available for Woods Hole Oceanographic Institution's PARKA I operations. The ship change was necessary because the operation assignment for Phases 1 and 2 required the extended range that could be provided by REXBURG. REXBURG was not available for Phase 0 operations.

(4) Phase 1

The Phase 1 operation began 0800, 14 August 1968 at 22°N on the PARKA I track. REXBURG proceeded to the operating area at 9.5 knots. Towing of the thermistor chain began at 0000, 19 August 1968 at 37°N and continued along the PARKA I track until 0700, 22 August 1968 at 45°N. It was decided to begin towing considerably south of 41°N, the assigned starting point, to insure proper coverage of the water mass boundary. Ship's course was reversed at 0730, 22 August 1968 at 45°N. The thermistor chain was then towed south along the PARKA I track until 1000, 24 August 1968 when Phase 1 operations ended at 40°N.

(5) Drift Station

During the period from 1600, 24 August to 0630, 26 August 1968, REXBURG drifted in order to conserve fuel while awaiting the approach of the Phase 2 source ship. During this period REXBURG drifted from 30°56'N, 158°08'W to 39°51'N, 157°19'W (about 50 nm). The thermistor chain was in operation continuously throughout the drift station. BT messages derived from thermistor chain data were logged and transmitted in the same manner as Phases 0 and 1.

(6) Phase 2

Upon termination of the drift station, the thermistor chain was retrieved and REXBURG proceeded to the assigned Phase 2 operating area (41°N to 45°N). Phase 2 thermistor chain operations began on the PARKA I track at 41°10'N at 1900, 27 August 1968. The chain was towed northward through the water mass boundary region. Ship's course was reversed at 0730, 29 August 1968 at 44°35'N and the southward return crossing of the boundary region began.

Through radio communications to the OCC Kaneohe and to NURDC, REXBURG mutually agreed the remaining Phase 2 thermistor chain operating time should be invested in the southern portion of the PARKA I track, near 28°N. At 1800, 29 August 1968 thermistor chain operations were terminated at 43°25'N and REXBURG proceeded south along the PARKA I track. With fuel consumption being the regulating factor, the maximum number of remaining operating hours was calculated. It was determined REXBURG would resume chain operations at 32°N and tow the chain south to as near 22°N as remaining fuel would allow.

Thermistor chain operations resumed at 2300, 1 September 1968 at 32°N. The chain was towed at six knots southward along the PARKA I track to 24°N where Phase 2 thermistor chain operations ended at 0800,

5 September 1968. REXBURG then proceeded to Pearl Harbor arriving at 0900, 6 September 1968.

b. **Instrumentation**

The NURDC thermistor chain and data system were used during Phases 0, 1, and 2 of the PARKA I Experiment. The thermistor chain measures temperature as a function of depth of the upper layers of the ocean as it is towed at six knots along the ship's track. The towed thermistor chain was developed at Woods Hole Oceanographic Institution (WHOI). The chain discussed here is essentially the same mechanical configuration as WHOI's (Richardson, 1959). However, the electronics has been updated to keep pace with technological advances since 1961. The current data system interfaced with a digital computer is described below.

Forty-seven thermistors, spaced at 5.1 meter intervals along the chain, continuously sense the ocean temperature. The thermistors are calibrated to an accuracy of ±0.002° Celsius. The sensors are thermally lagged to have a response time of twenty seconds. The thermistors are scanned every ten seconds and the temperature is recorded in digital form on an incremental magnetic tape recorder. The temperature accuracy for the digital data system is ±0.05° Celsius. The digital system is interfaced with the shipboard UNIVAC 1218 computer for real-time data analysis.

The towed configuration of the thermistor chain is a modified catenary and the chain responds as a semi-rigid body. A family of curves has been derived that accurately describes the chain configuration as a function of the towing speed through the water.* The configuration and therefore the sensor depths is known for each 10 second scan. This method essentially eliminates errors in the data caused by vertical motion of the chain. The accuracy of sensor depths is ±0.2 meter. A single scan of digital data consists of 47 temperature measurements, the output of two calibrate resistors, and the maximum towing depth. The calibrate resistors show any electronic drift in the system and the temperature data are corrected with a slope-intercept formula. The maximum towing depth at the time each scan is recorded is used as a parameter to select the proper set of equations to compute the depth of each thermistor.

A block of data contains nine scans of the sensors with 50 data points to a scan plus one additional datum with time information. The shipboard computer, in real-time, computes the average (equal weight) and standard deviation of each output over one block of nine scans, and the averages over a number of blocks preset from 2 to 63. This corresponds to a time range from 3 to 94.5 minutes as a preset interval for averaging.

c. **Data Acquisition and Analysis**

The temperature data derived from the thermistor chain during the PARKA I Experiment were averaged over an interval of one hour, or 40 data blocks. The averaging interval was symmetric about integral values of each hour, i.e., 0000, 0100, . . . , 2300. Temperature corrections were made and mean sensor depths were computed for each interval. A bathythermogram was logged in standard message form for each set of hourly averages. Every sixth message was transmitted to FWC, Pearl Harbor. The averaged temperature-depth data were plotted along the PARKA I track and the depth of whole degree Celsius isotherms were contoured.

*A Technical Report is in preparation, Smith, E. L.

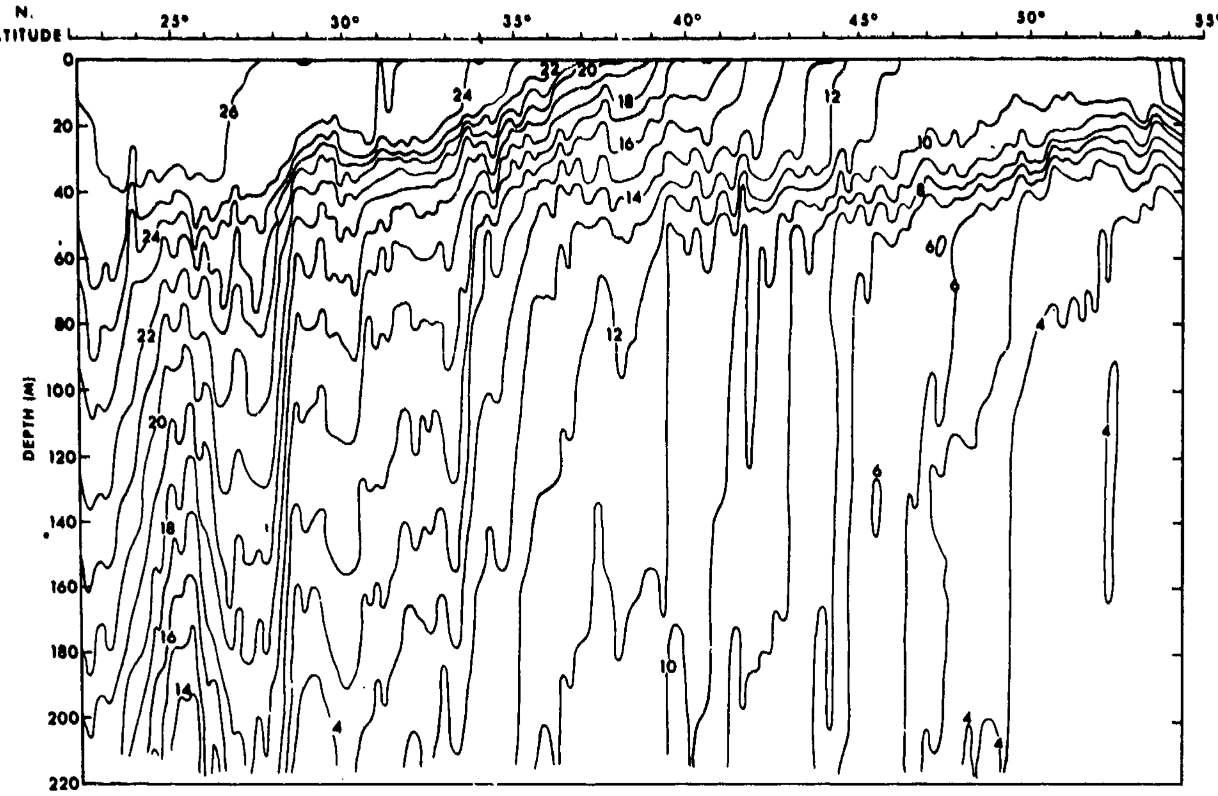

Fig. B-9 – Temperature structure profile from hourly averages derived from continuous NURDC thermistor chain data along 157°50′ W during Phase 0, 2000, 22 July to 2000, 5 August (increasing time north to south). Temperature in degrees C (U).

During the PARKA I Experiment 592 bathythermograms were derived from the thermistor chain data. XBT's were used during periods when the thermistor chain was not in operation; 55 records were obtained from this instrument.

d. Results

(1) Phase 0, 22 July – 5 August 1968

The temperature structure from Phase 0 is shown in Figure B-9. The structure displays three gross features: (a) the front at the water mass boundary, centered around 39°N; (b) a region of strong horizontal temperature gradient at about 28°N; and (c) a dome in the temperature structure at about 25°N. Each feature is discussed separately in subsequent paragraphs.

(a) Front at 30°N

Uda (1959) describes a front as the boundary between two different water masses. Such a front is formed at the boundary between the Subarctic Water and the Eastern and Western North Pacific Water masses (Sverdrup, et al., 1942). The front is usually centered around 43°N as determined from FNWC archival data. However, during late July 1968 the front was located considerably farther south.

The latitude at which the 18°C isotherm comes to the surface will be used here as an indicator to mark the center of

the front. The 18°C isotherm comes to the surface at about 39°N. Between 36°N and 39°N the 22°C to 19°C isotherms come to the surface froming a region of high horizontal gradient. North and south of this latitude band the isotherms rise to the surface sharply to form weaker horizontal gradients. Progressing from south to north through the front, the thermocline gradually cools and its vertical gradient becomes weaker. This pattern continues to about 46°N where only a slight upward trend of the isotherms is noticeable. The isotherms below 60-80 meters also rise to the north, and in general, do so more abruptly than the isotherms in the thermocline between 20 and 60 meters.

The magnitudes of the vertical and horizontal temperature gradients change with depth and latitude within the bounds of the front. The vertical temperature gradient in the upper 50 meters between 35°N and 39°N (the southern half of the front) is of the order 10^{-1}°C/m. The corresponding horizontal temperature gradient is of the order 10^{-2}°C/km (10^{-5}°C/m). At depths between 50 and 215 meters in the same region the orders of vertical and horizontal gradient are 10^{-2}°C/m and 10^{-3}°C/km (10^{-6}°C/m), respectively. The vertical temperature gradient north of the front center, between 39°N and 46°N in the upper 50 meters depth, is of the order 10^{-2}°C/m. The corresponding horizontal temperature gradient is of the order 10^{-2}°C/km (10^{-5}°C/m). At depths greater than 50 meters in the northern portion of the front the vertical temperature gradient is of the order 10^{-3}°C/m and the corresponding horizontal temperature gradient is of the order 10^{-3}°C/km (10^{-6}°C/m).

(b) Horizontal Gradient at 28°N

Moving southward along the track (Fig. B-9) to about 28°N another obvious feature is encountered. A strong horizontal temperature gradient is formed by large depth changes in the 15°C to 24°C isotherms. The magnitude of the horizontal gradient is 0.2°C/km. The gradient persists over 15 kilometers. This gradient is one order smaller than vertical gradients in the permanent thermocline and about two orders smaller than vertical gradients in the surface layers.

(c) Dome at 25°N

The third large scale feature is the dome centered around 25°N. Most isotherms in the region of the dome are displaced upward about 70 meters from what appears to be their normal depths.

Domes of this size, about 200 kilometers across, are not unusual in the vicinity of the Hawaiian Islands and can be associated with the cyclonic eddies (Smith, 1967). However, eddies to the north of the Islands are seldom observed. The amount of vertical displacement of isotherms decreases toward the surface. The presence of the dome is masked near the surface by the wind-mixed layer.

The depth of the mixed layer changes markedly over the track. In the south the mixed layer depth is about 40 meters. The layer becomes shallower to the north to about 35°N where it nearly disappears. From 40°N to 45°N the depth of the mixed layer increases again to about 40 meters. From 45°N to the end of the track the mixed layer depth rises gradually from 40 meters to 20 meters depth.

(2) Phase 1, 19 – 24 August 1968

The temperature structure from Phase 1 is shown in Figures B-10 and B-11. Figure B-10 is the result of the south to north tow of the thermistor chain through the water mass boundary region. Figure B-11 is the result of reversing course and towing from

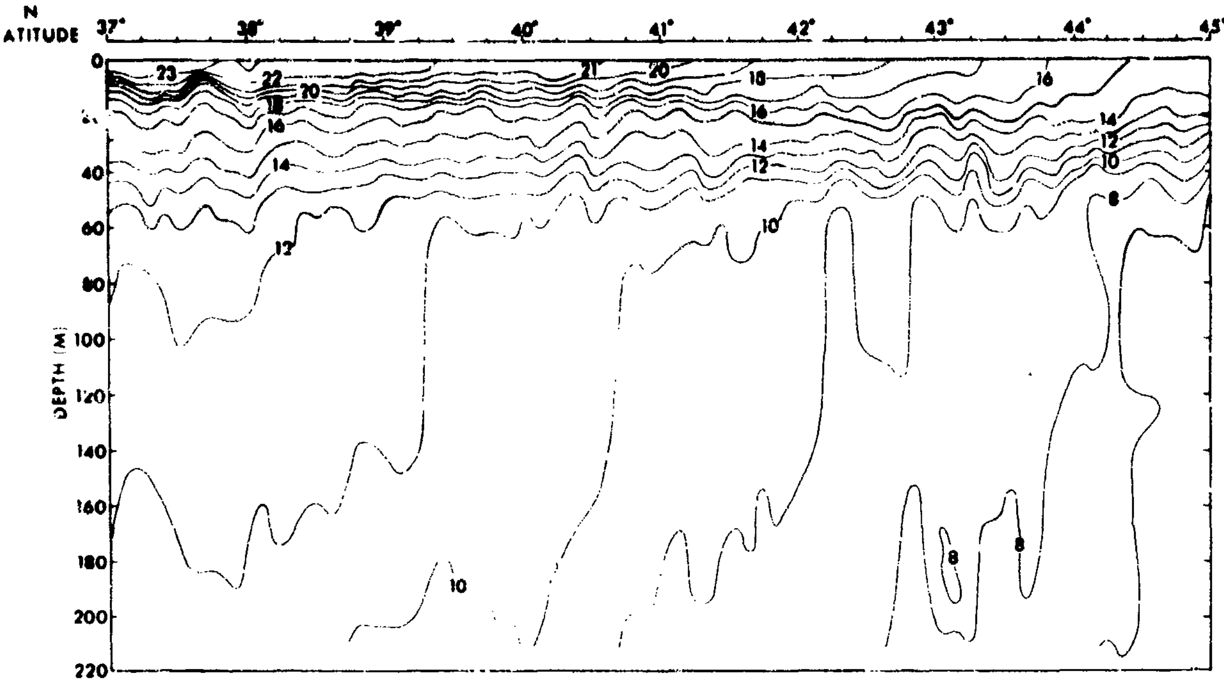

Fig. B-10 – Temperature-structure profile from hourly averages derived from continuous NURDC thermistor chain along 157°50′ W during Phase 1, 0000, 19 August to 0700, 22 August (increasing time south to north). Temperatures in degrees C (U).

north to south through the front. Because of the southerly position of the front during Phase 0 (39°N), the south to north tow began at 37°N (Fig. B-10). This precautionary measure proved to be unnecessary as the front was found in its northerly position at about 42°45′N. As in Phase 0, the 18°C isotherm is used as an indicator for the center of the front.

The general character of the water mass boundary front did not change greatly between Phase 0 and Phase 1. However, the position change of about 350 kilometers is a startling result. A meander or migration of this magnitude is comparable to features found in the region of the Kuroshio and Gulf Stream.

Progressing from south to north (Fig. B-10) the thermocline becomes weaker. The deep isotherms undergo large depth changes. Special note should be made of the 7°C, 8°C, and 9°C isotherms north of 42°N. The 7°C and 8°C isotherms show weak inversions around 100 meters depth north of 44°N. A pinnacle is formed by the 9°C isotherm at about 42°15′N. The significance of this feature will be shown in the following discussion of Figure B-11. A pocket of 8°C water is shown at 200 meters depth.

After passing through the front, ship's course was reversed at 45°N and the north to south tow back through the front was completed. The contoured temperature structure for the north to south section is shown in Figure B-11. The temperature structure in the upper layers is basically the same as for Figure B-10. The position of the front has not varied greatly, although the position where the 18°C isotherm comes to the surface is about 42°25′N. This is a position change of 30 kilometers to the south as compared to

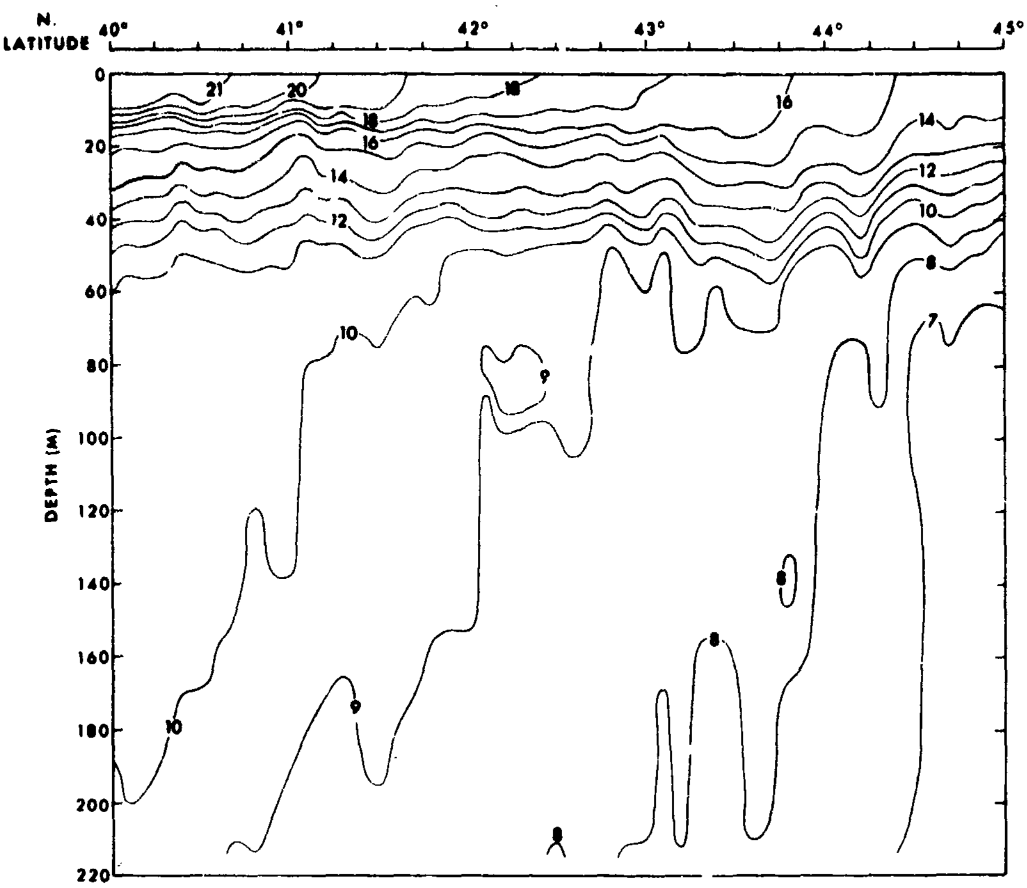

Fig. B-11 – Temperature structure profile from hourly averages derived from continuous NURDC thermistor chain data along 157°50′ W during Phase 1, 0800, 22 August to 1000, 24 August (increasing time north to south). Temperature in degrees C (U).

Figure B-10. However, the neighboring isotherms (15°C to 20°C) are in nearly the same position for both temperature sections.

Large changes in the temperature structure took place at depths greater than 80 meters. At 42°15′N the 9°C pinnacle has been severed leaving a pocket of 9°C water. North of 44°N the inversion in the 8°C isotherm has vanished and the 7°C inversion is much weaker than noted in Figure B-10. A small pocket of 8°C water is shown at about 150 meters depth.

(3) Phase 2, 27 August – 5 September 1968

The temperature structure of the front in the water mass boundary region was recorded during the first part of Phase 2. The results are shown in Figure B-12 A and B. Figure B-12A is the result of the south to north tow. Using the positions at which the 16°C to 19°C isotherms come to the surface as position indicators, the front appears to be nearly stationary as compared to Phase 1. The mixed layer and therefore the thermocline

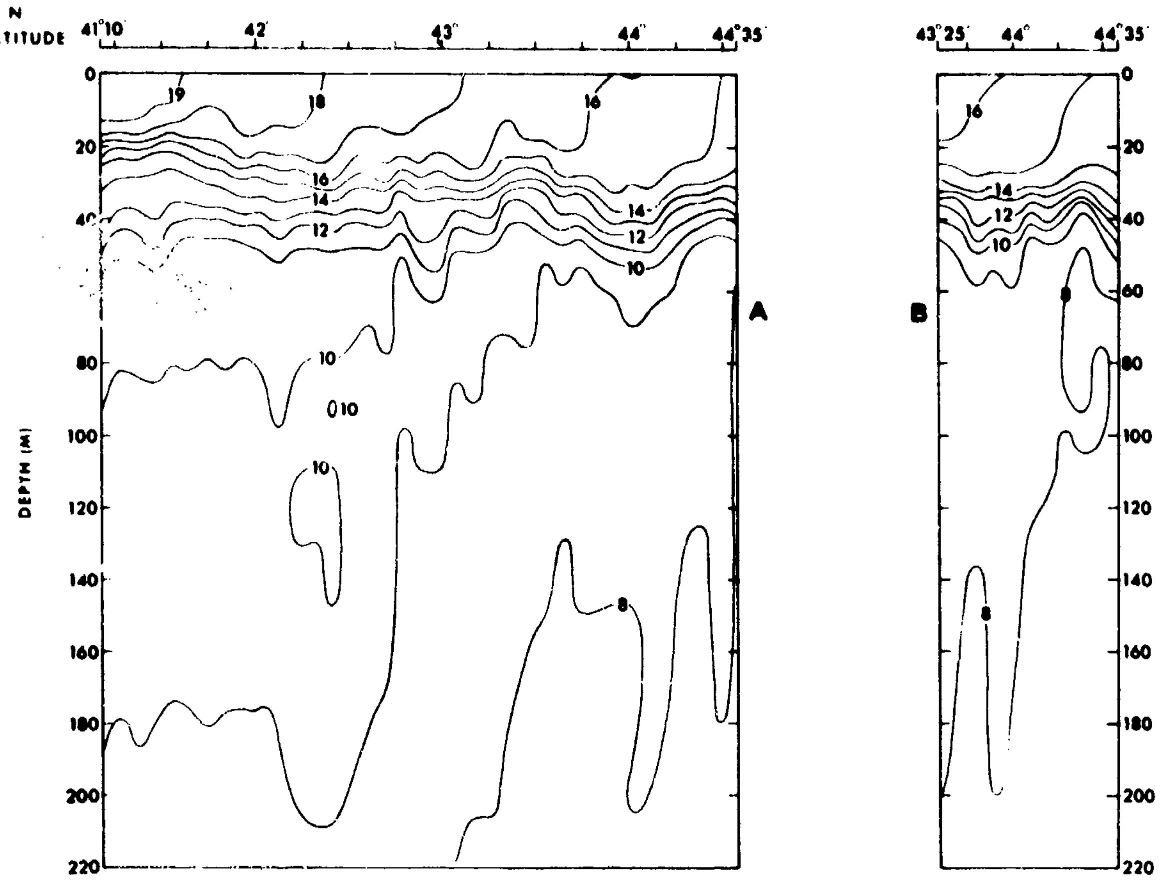

Fig. B-12 – Temperature structure profile from hourly averages derived from continuous NURDC thermistor chain data along 157°50' W during Phase 2, (A) 1900, 27 August to 0700, 29 August (increasing time south to north), (B) 0800, 29 August to 1800, 29 August (increasing time north to south). Temperature in degrees C (U).

are deeper than in Phase 1. This may have been caused by increased wind velocities during Phase 2. Two pockets of 10°C water are noted at 42°15'N. A temperature inversion in the 8°C isotherm at 180 meters depth and north of 44°N is also noted.

Figure B-12B shows the contoured temperature structure in the frontal region after reversing ship's course. This section is relatively short but shows increased activity in the 8°C isotherm in a short period of time. The front was considered to be stationary with regard to any large scale changes in and near the thermocline. Therefore, surveillance of the front was terminated at 43°25'N and thermistor chain operations moved south.

Temperature structure profiling resumed at 32°N and proceeded south to 24°N. This is the region previously noted in Phase 0 as having a strong horizontal temperature gradient and a dome in the temperature structure. Figure B-13 shows the contoured temperature results of this section late in Phase 2. The latitude scale is greatly exaggerated compared to the corresponding section recorded during Phase 0 (Fig. B-9). On this scale the region of strong horizontal temperature gradient at 28°N is not as conspicuous as pre-

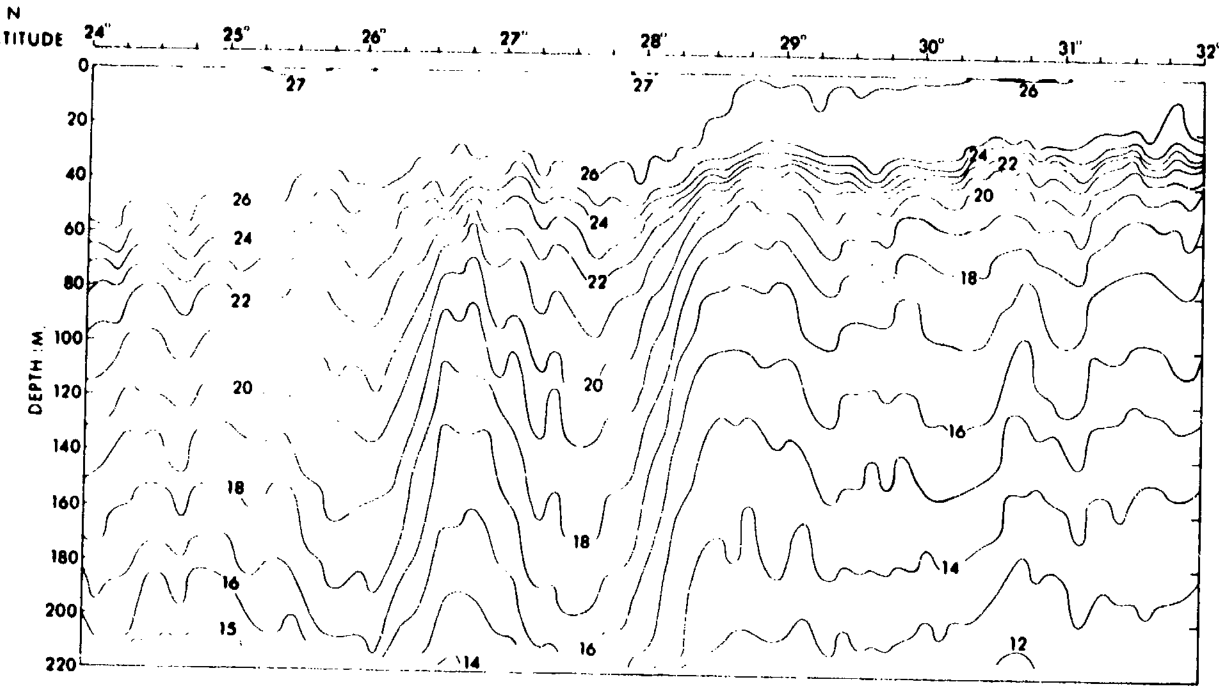

Fig. B-13 – Temperature structure profile from hourly averages derived from continuous NURDC thermistor chain data along 157°50′ W during Phase 2, 2300, 1 September to 0800, 5 September (increasing time north to south). Temperature in degrees C (U).

viously described. Instead the dome centered around 26°40′N is the stronger feature and the horizontal temperature gradient appears to be associated with the dome. The horizontal temperature gradient between 26°N and 28°30′N is about 7 X 10^{-2}°C/km (7 X 10^{-5}°C/m) between the 40 and 200 meters depth. The dome is about 125 kilometers in diameter. The center of the dome is about 150 kilometers to the north of that observed during Phase 0. Assuming the dome is caused by a cyclonic eddy and this is the same eddy as observed in Phase 0, the migration rate would be 5 kilometers per day, which is a reasonable translation rate for Hawaiian eddies (Smith, 1967). The effects of the dome are masked at depths less than 50 meters by the wind-mixed layer. Further measurements would be necessary, particularly in an east-west direction, to conclude the dome is caused by a cyclonic eddy.

The depth of the mixed layer increases to the south as the increased influence of the Trade Winds would be expected. Surface temperatures increased about one degree C over the area as compared to Phase 0.

e. References

Richardson, W. S. and C. J. Hubbard, "The Contouring Temperature Recorder," *Deep Sea Research*, v. 6, p. 239-244, 1959-1960.

Smith, E. L., "Migration and Temperature of Eddies on the Leeward Side of the Hawaiian Islands," *Fourth U.S. Navy Symposium on Military Oceanography; Proceedings*, v. 1, p. 396-414, 10-12 May 1967.

Uda, M., "On the Structure of the Boundary of Water Masses," *Jour. Ocean. Soc. of Japan*, 2(4):9-16, 1943.

Sverdrup, H. U., M. W. Johnson and R. H. Fleming, "The Oceans: Their Physics, Chemistry and Biology," *Prentice Hall*, N.Y., 1942.

8. Aircraft Expendable Bathythermograph Observations

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a. General

Nine aircraft flights, by Patrol Squad-on 28, utilizing AXBT's, took place between 16 August and 5 September 1968 along the PARKA I track (157°50'W) to measure temperature as a function of depth and latitude in a synoptic manner during the acoustic experiments. Table B-IV shows the flight number, date, time, latitude of the first and last AXBT drops and the number of drops for each flight.

The AXBT data were processed by FNWC, and are presented as cross-sectional plots along the flight track as shown in Figure B-14. Temperature is contoured in whole degrees Celsius at three degree intervals.

Sound velocity structure was computed from AXBT data and FNWC archival salinity data. Figure B-15 shows the cross-sections of

Table B-IV (U)
Aircraft Expendable Bathythermograph Data Flights

Flight Number	Date	First Drop		Last Drop		Number of Drops
		Time	Latitude	Time	Latitude	
1	16 August	1114W	43°00'N	1643W	23°30'N	40
2	17 August	1102W	43°00'N	1627W	22°00'N	44
3	19 August	0809W	55°00'N	1653W	22°00'N	72
4	22 August	0800W (approx)	55°00'N	1700W (approx)	22°36'N	76
5	27 August	1053W	42°24'N	1642W	22°00'N	43
6	30 August	1123W	42°48'N	1709W	26°36'N	27
7	31 August	1053W	43°00'N	1636W	22°06'N	43
8	02 September	0801W	54°36'N	1651W	22°06'N	70
9	04 September	0804W	54°36'N	1649W	22°12'N	69
						484

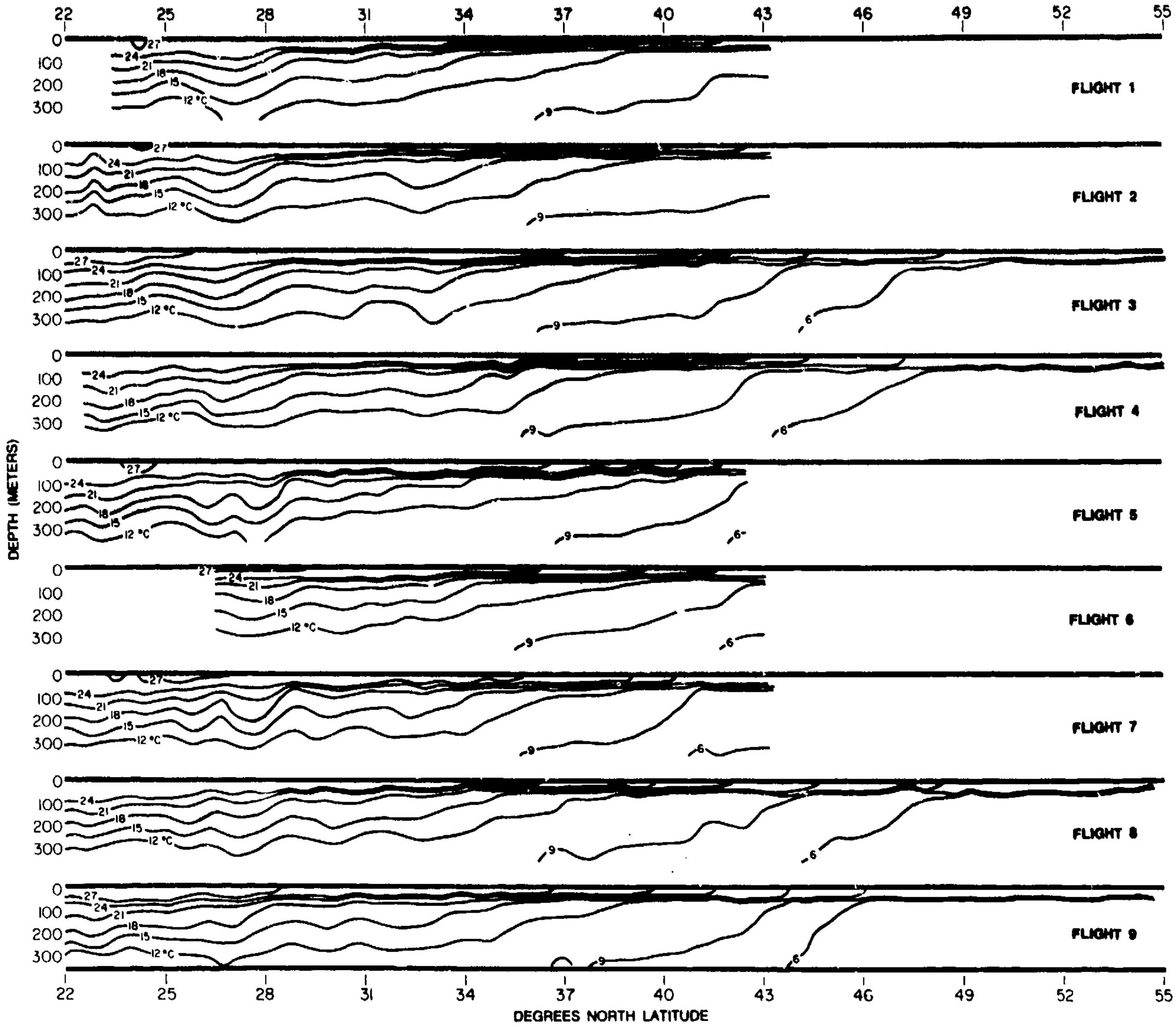

Fig. B-14 – Temperature (degrees C) time series of synoptic AXBT sections (depth (m) vs latitude). (U).

sound velocity structures along the PARKA I track. Isolines of sound velocity essentially parallel isolines of temperature; consequently, further discussion here is restricted to temperature structure (Fig. B-14).

The temperature cross-sections display three gross features: (1) the front at the water mass boundary, centered near 42°N, (2) a region of strong horizontal gradient at about 27°30'N, and (3) a dome in the isotherms that varies in position between 24°N and 26°N. Each feature is discussed separately in subsequent paragraphs.

b. Water Mass Boundary (Front at 42°N)

A front is formed in the transition region between the Subarctic Pacific and the North

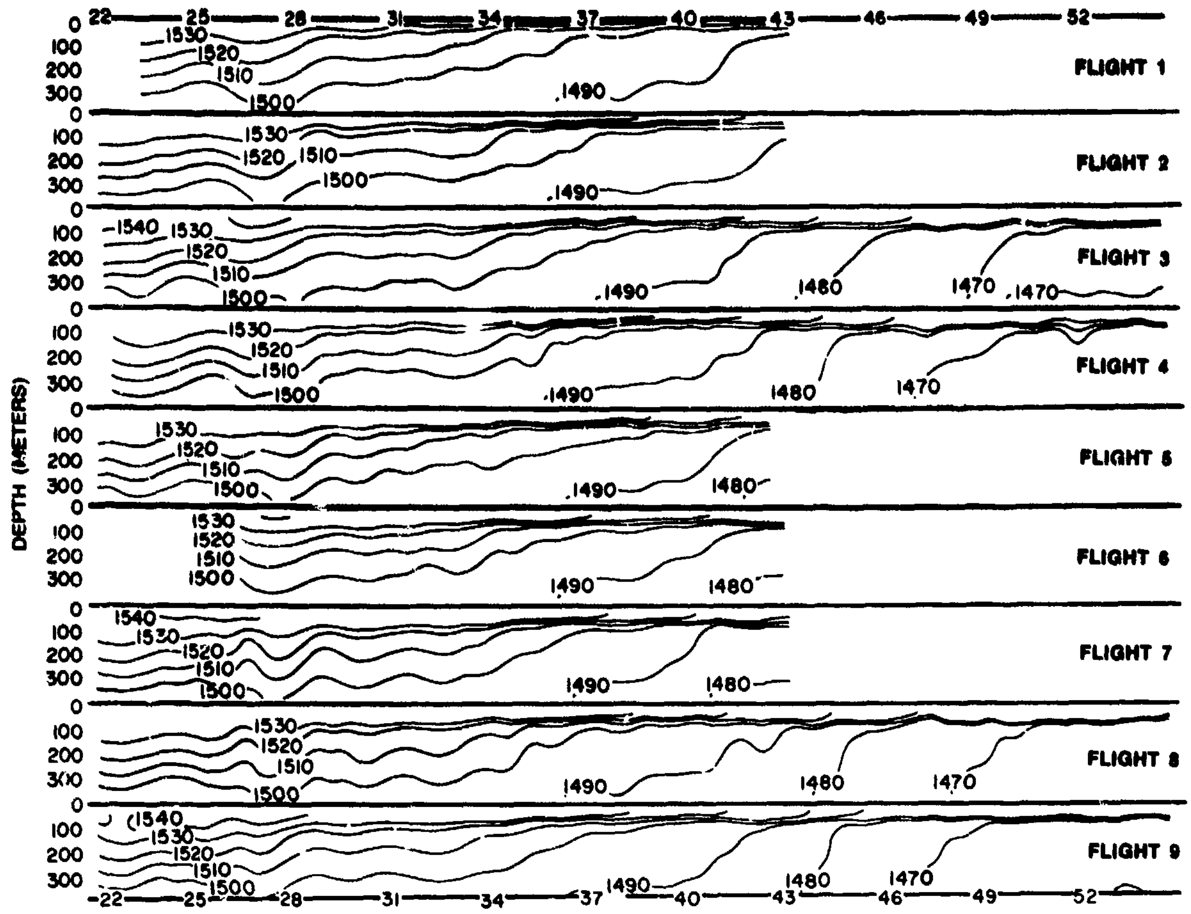

Fig. B-15 – Sound velocity (m/sec) time series of synoptic AXBT sections (depth (m) vs latitude) (U)

Pacific Central water masses. Frontal regions are generally characterized by increased horizontal temperature gradients, scattered temperature inversions, increased vertical displacement and step-like changes in mean conditions of scalars.

Not all flights covered the entire PARKA I track, although each penetrated the frontal region. Flights three, four, eight, and nine covered the entire track and best show the general character of the front. The latitude at which the 18°C isotherm comes to the surface is used as an indicator to mark the center of the front. The position of the center of the front changes from flight to flight and ranges between 40°25'N to 42°35'N. The mean position of the center is 41°47'N. Although the front's position remained nearly fixed during the acoustic experiments, a large translation was noted between Phase 0 and Phase 1. Details are given on pages 34-37.

The mean vertical temperature gradient in the upper 75 meters between 40°N and 44°N is of the order 10^{-2}°C/m. The corresponding mean horizontal temperature gradient is of the order 10^{-2}°C/km (10^{-5}°C/m). At depths between 75 and 335 meters in the same region the orders of vertical and horizontal tempera-

ture gradients are 10^{-3}°C/m and 10^{-3}°C/km (10^{-6}°C/m), respectively.

c. **Subtropical Front (Region of Strong Horizontal Gradient 27°30'N)**

An area of strong horizontal temperature gradient was recorded during all flights near 27°30'N. Isothermal surfaces are displaced 40 to 60 meters over a distance of about 50 kilometers inside the front. The horizontal temperature gradient is of the order 10^{-2}°C/km (10^{-5}°C/m) over the width of the front (about 90 kilometers). The vertical gradient is of the order 10^{-2}°C/m.

Position and character of the front recorded during flights five and seven differ markedly from those recorded on other flights. These data show a dome of colder water 60 kilometers in diameter immediately south of the front which was displaced northward of its previous position by about 45 kilometers. Vertical displacement of isotherms in the dome is about 50 meters and only the isotherms below 100 meters depth are noticeably affected.

d. **Thermal Dome at 24°N to 26°N**

A well-defined high or rise in the temperature structure was recorded during the first five flights near 25°N. Based on prior studies in this area, it seems likely that this feature also extends somewhat east and west of the PARKA I track, making it a dome of colder water. A more detailed discussion of the reasons for this conclusion is included on pages 35 and 38-39. The diameter of the dome is about 200 kilometers. In the center, isotherms rise about 50 meters above their normal depths. Domes of this size have been associated with cyclonic eddies near the Hawaiian Islands (Smith, 1967); however, eddies north of the islands are seldom observed. Vertical displacement of isotherms decreases toward the surface and is finally masked by the wind-mixed layer.

In the structure recorded during flight five, the large dome is recognizable but modified by the appearance of two smaller domes, one to the north, the second to the south. The structure of flight seven shows the large dome absent or concealed by a small dome at 26°50'N plus several vertical displacements of the isotherms toward the south end of the track. The large dome is not apparent in either of the last two flights. Instead, smaller domes or oscillations of the isotherms dominate the structure from 26°30'N south to 22°N.

e. **Mixed Layer Depth**

The depth of the wind-mixed layer changes considerably over the track. In the south the mixed layer depth is between 40 and 50 meters. The layer becomes shallower progressing northward to about 36°N where it nearly disappears. The layer remains shallow between 36°N and 42°N which corresponds to a region of high pressure during the majority of the experiment (see page 27). The depth of the layer begins to increase again at 42°N and continues increasing to about 50°N where it remains at 40 meters until near the northern end of the track. Near 53°30'N a slight upward trend begins and the layer rises to 20 meters depth at 55°N.

f. **Thermocline Characteristics**

The strength and depth of the thermocline varies widely with latitude. In the southern portion of the track, 22°N to 27°30'N, the isotherms are nearly evenly spaced. In the thermocline the vertical temperature gradient is about 4×10^{-2}°C/m throughout the depth range of 335 meters.

Between 27°30'N and 36°N a two-layer structure begins to form. The vertical gradient in the seasonal thermocline increases with latitude as the deeper isotherms rise toward the surface. In the upper 100 meters the vertical temperature gradient is 8×10^{-2}°C/m while that below is 2×10^{-2}°C/m.

From 37°N to 55°N the gradient in the seasonal thermocline gradually weakens. The vertical temperature gradient in the thermocline, above 100 meters, is 5×10^{-2}°C/m and that below and within the sampling depth is 8×10^{-3}°C/m.

g. **Reference**

Smith, E. L., "Migration and Temperature of Eddies on the Leeward Side of the Hawaiian Islands," *Fourth U.S. Navy Symposium on Military Oceanography; Proceedings,* v. 1, p. 396-414, 10-12 May 1967.

9. Salinity

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a. **General**

During the PARKA I experiment, only R/V CONRAD and R/V TERITU carried STD systems capable of measuring salinity at depth. During the actual period of the acoustic experiment in Phases 1 and 2, only TERITU collected salinity data on a regular basis, making STD measurements to a depth of 1500 meters between 22°N and 30°N (page 49). CONRAD was the source ship during Phase 1, and was therefore unable to stop for deep measurements. During Phase 2, difficulty with the salinity sensor made the data suspect. CONRAD did, however, make several deep measurements in Phase 0 and Phase 3.

b. **FNWC Climatological Data**

Propagation loss forecasts computed for PARKA I by FNWC were based on archival temperature and salinity profiles derived from climatological Nansen cast data. The mean values for the months of August and September were used for each point required along the track north from Hawaii.

Most of the sound velocity profiles shown in Figures B-3 to B-7 were computed from XBT data and the temperature output from SVP and some STD stations, combined with climatological salinity values. These mean salinities were derived from archival Nansen cast data from August and September, and represent the best estimate of salinity values along the PARKA I track in the absence of any actual measurements during the experiment. Only in the area south of 30°N covered by TERITU were there any PARKA salinity data to use in computing sound velocity.

c. **PARKA Measured Data**

Salinities measured by TERITU during PARKA I produced few surprises. Surface values increased from about 34.6‰ at 22°N to about 35.4‰ at 30°N. The vertical gradient is quite marked down to a depth of 400 meters, then becomes much more gradual to the bottom of the profile at 1500 meters.

The salinity data accurately reflect regions of increased horizontal gradient or thermal front observed between the surface and a depth of 200 meters throughout the experiment in the area around 28°15'N. In addition, there is a "dome" in both temperature and salinity around 25°N during most of the period. There is a tongue of low salinity water extending southward at a depth of about 450 meters, which is most likely caused by the presence of the North Pacific Intermediate water mass, which usually occurs at these depths.

A more complete discussion of the variability of the major features of the salinity regime is contained in Appendix B10, which follows.

10. HIG Oceanographic Operations

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a. **Objectives**

(1) Phase 0

HIG's objectives were to provide Fleet Numerical Weather Central with as much detailed information as possible concerning the water mass structure along the PARKA I track from 22°N to 30°N and the details of the bottom profile along this track from Oahu to 30°N in order to assist FNWC in making acoustic transmission loss predictions using predictive models presently in existence. The environmental data and bathymetry are applicable to the later phases for predictive modeling and interpretation. These data were used to assess the nature and the variability with time of the sound velocity profiles (SVP's) for determining the schedule of SVP's to be taken during later phases.

(2) Phase 1

During this Phase, HIG assisted in obtaining salinity and temperature versus depth (STD) measurements from Oahu to 30°N along the PARKA I track and obtained deep velocimeter data and bathymetry along this track from 43°N to 49°N. Expendable bathythermographs were used between STD and SVP stations to further delineate changes in the environmental data observed. These data were relayed to FNWC for use in updating the acoustic transmission loss prediction model designed as a result of environmental data obtained during Phase 0.

(3) Phase 2

The objectives were the same as Phase 1.

(4) Phase 3

During Phase 3, HIG provided a source ship to operate in close proximity to the re-

ceiving ship at each of three locations along the PARKA I track. It's purpose was to obtain bottom acoustic reflectivity data over a broad ocean area as a function of angle and frequency. These will be used as inputs to the ray tracing program at FNWC to compute and predict intensity. Phase 3 operations support the program of acoustic measurements of bottom reflectivity and long baseline signal coherence covered in Appendix F.

b. Instrumentation

(1) R/V TERITU

For all three runs of Phase 0, navigation was by means of Loran A, Loran C, dead reckoning, and reconstruction of position by calculating shot travel time from ship to Pacific Missile Range (PMR) Facilities at Kaneohe and Midway. Shot travel times were not used in Phases 1 and 2. Salinity, temperature, and depth were obtained by a Bissett-Berman STD lowered to 1500 meters. Recording was by analog plot, punched tape, and teletypewriter. A Sippican XBT recorder and launcher were used with expendable bathythermographs to a depth of 1500 feet in Phase 0 and to a depth of 2500 feet in Phases 1 and 2. Bathymetry was obtained with a UQN-1 transducer towed at 80 feet and an Alpine PESR. For Phase 0 only, one SUS charge containing 1.8 pounds of TNT was fired at 800 feet before and after each STD lowering. Time of firing was recorded on the ship, and time of receipt was recorded at PMR Kaneohe and PMR Midway. A schematic track chart for TERITU operations in Phases 1 and 2 is shown in Figure B-16.

(2) R/V MIKIMIKI

Phases 1, 2, and 3: navigation was by means of celestial observations and Loran A. Ranges between source and receiving ship in Phase 3 were determined by radar to the limit of coverage and then by dead reckoning. Bathymetry was obtained by UQN-1 transducer towed at 130 feet and Alpine PESR. Sound velocity profiles were obtained to near the bottom by means of a NUS Corporation SVP system. Depth was obtained from pressure and the output of temperature, velocity, and depth are recorded on an analog plot and on punched tape. Shot time was recorded from a hydrophone on an NRL tape recorder. A schematic track chart for all MIKIMIKI PARKA operations is shown in Figure B-17.

c. Data Acquisition Procedures

(1) R/V TERITU

The STD probe was lowered from the surface to 300 meters at slow speed and from 300 meters to 1500 meters at high speed, 200 and 400 feet per minute, respectively. Data were recorded only while lowering. Expanded scales from the surface to 300 meters were used on the analog plot for greater accuracy. The record of salinity, temperature, and depth was punched on tape and printed by teletype every 1.8 seconds. Surface salinity samples and bucket thermometer temperatures were obtained at each station. The STD probe was factory calibrated immediately prior to Phase 1.

(2) R/V MIKIMIKI

A record of temperature, sound velocity, and depth was obtained every three seconds while the probe was being lowered. The lowering rate was 300 feet per minute. The scale on the analog plot was chosen to include maximum and minimum readings. The records consist of analog plot and digital punched tape. Surface salinity samples and

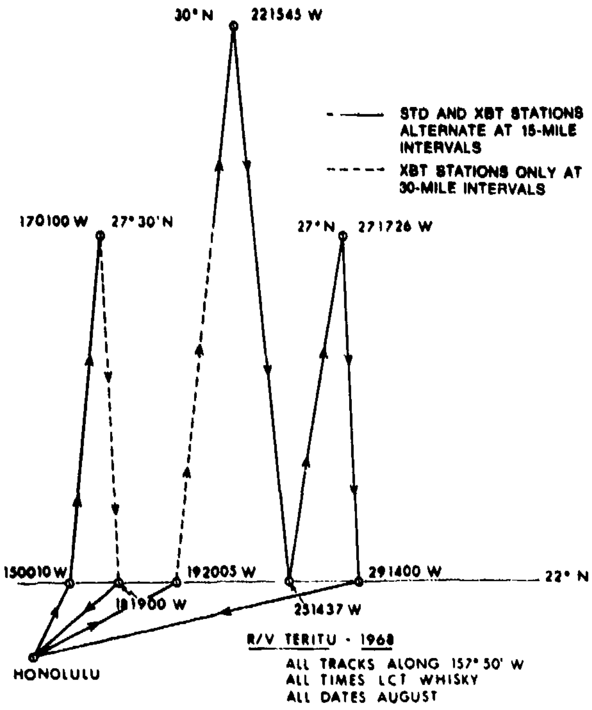

Fig. B-16 – TERITU schematic track chart (U)

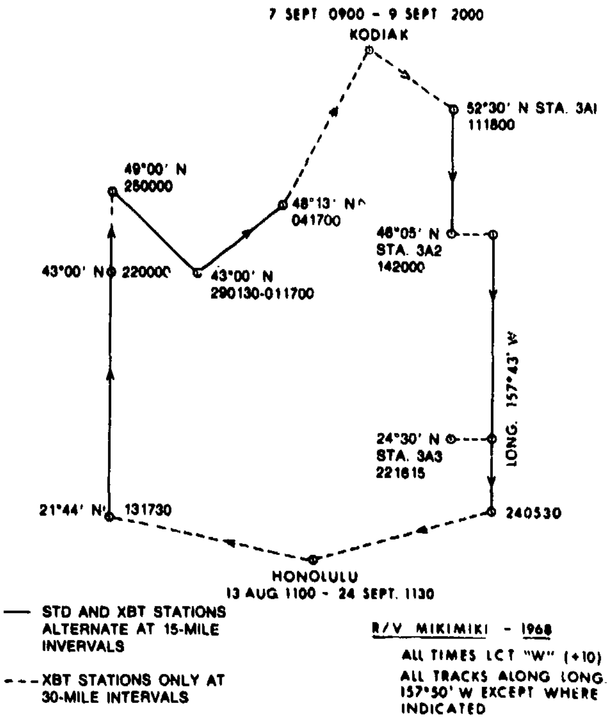

Fig. B-17 – MIKIMIKI schematic track chart (U)

bucket thermometer temperatures were obtained at each station. The velocimeter was factory calibrated immediately prior to Phase 1.

d. **Data Analysis Procedures**

(1) R/V TERITU

The digital record of salinity, temperature, and depth on punched paper tape was teletyped in HISTD format to the electronics laboratory of the Hawaii Institute of Geophysics following each station. The XBT record was placed in BATHY message format which was then punched on tape and telemetered to HIG. These messages were again transferred from tape to teletype printout at the electronics laboratory where they were picked up daily by messenger from FWC Pearl for transmission to FNWC. The eight level tape system of HIG is not compatible with the five level system of FWC Pearl. Future development will be aimed at telemetry of real time data direct to FNWC. The data from PARKA I were processed in the HIG computer center and then analyzed. Bathymetry obtained in Runs 1 and 2 of Phase 0 was mailed to PARKA participants in the form of bottom profiles along the PARKA track from 21°47'N to 30°N for use in planning for Phases 1, 2, and 3.

(2) R/V MIKIMIKI

Sound velocity data were coded in the HISTD code and transmitted to the Operation Control Center at Kaneohe via the Scientific Radio Network. The data and records from Phase 3 were collected by the Senior Scientist at the end of the PARKA Experiment and delivered to NRL. Data were processed in the HIG computer and analyzed.

e. **TERITU Operations in Phase 0**

(1) The first cruise was made from 21 to 29 May 1968. The STD stations to 1500 meters were planned at 20-nm intervals along, 157°57'W commencing at 22°N and extending due north to at least 30°N. Return was to be along the same track with stations repeated exactly in order to observe relatively short period changes in water structure. XBT stations to a depth of 1500 feet were planned midway between STD stations for better delineation of water mass characteristics. Eighty SUS charges were obtained from ASWFORPAC and were planned to be fired at 60 and 800 feet at each STD station in an effort to correlate travel time and acoustic amplitudes with observed velocity profile. Time of explosion was recorded on board ship on magnetic tape and chart recorder and the signal arrival was recorded at PMR Kaneohe. The newly acquired Ocean Research towed transducer vehicle with UQN-1 transducer was used to record bathymetry on an Alpine PESR. Difficulties were experienced with the STD probe resulting in only 24 STD stations being obtained. The end station was at 29°40'N. Even while making a speed of seven knots, the 60-ft SUS explosions shook TERITU and caused damage aboard ship. Therefore shallow detonations were discontinued after the fourth station. The remaining SUS charges were exploded at 800 feet with one prior to and one following each STD station until the STD failed. Following the STD failure XBT stations were made at 10 nm intervals with one SUS explosion at each station. The track was reversed at 31°N. XBT stations were made at 10 nm intervals on the return track until the last XBT was expended with the last SUS charge at 27°20'N. BATHY messages were telemetered to the HIG Electronics Laboratory where they were picked up by messenger from FWC Pearl and transmitted to FNWC Monterey. Good bathymetry was obtained throughout, and was made available to the other PARKA participants in June 1968.

(2) TERITU made the second PARKA cruise from 19 to 28 June 1968. The basic plan for STD and XBT stations was the same as for Run 1, except that the track position was shifted to 157°50'W. Eighty SUS charges were exploded at 800 feet, one before and one after each STD station. The track was reversed at 30°20'N. Fifty STD stations were made to 1500 meters with station positions on the return leg repeating those made during the transit north. The last STD station was made at 22°40'N. Fifty XBT drops to 1500 feet were made. Only one obvious failure occurred in the total of 83 XBT drops. Bathymetry was not obtained except between 22°N and 28°N due to failure of the Alpine PESR. Nansen casts to 1400 meters and to 900 meters were made at 29°N as a check on the STD. Surface salinity samples and bucket thermometer temperatures were obtained at each station for the Bureau of Commercial Fisheries (BCF) Honolulu. BCF will analyze the salinities of these 119 samples, including the Nansen casts and will report the results to HIG. After a telemetry failure BATHY and HISTD messages were transmitted by voice radio to HIG. These 99 messages were picked up by FWC Pearl and transmitted to FNWC Monterey. Acoustic travel time from PMR has proven to be an excellent means of fixing the ship's position after the run. It is anticipated that the amplitude of the received signal will provide useful information and can be correlated with the time-variability in the sound velocity profiles.

(3) The third PARKA cruise was made from 19 to 28 July 1968. The basic plan was

the same as for Run 2. Sixty-eight SUS charges were set to detonate at 800 feet; two were duds. The track was reversed at 30°02'N. On the northbound track STD casts on Stations 9 through 16 were not made due to adverse sea conditions. On southbound track, 25 STD stations were made. The instrument and counter appeared to give good results after the repairs and calibration following Run 2. All but two of the fifty 1500 foot XBT probes gave good results. Bathymetry was not obtained except between 22°N and 27°21'N due to a grounded cable between transceiver and transducer. Ninety-nine surface salinity samples with bucket thermometer temperatures were obtained for BCF Honolulu. HISTD and BATHY message reports were made for each station. Seventy-five reports were sent by teletype to HIG Electronics Laboratory and 20 were delivered by hand on return to port. These were picked up by FWC Pearl for transmission to FNWC Monterey.

f. TERITU Operations in Phases 1 and 2

(1) The PARKA I Experiment Operation Plan scheduled TERITU for Phases 1 and 2 for oceanographic observations at 30 nm intervals along the PARKA I track from 21°47'N to 30°N using the STD equipment to a depth of 1500 meters. XBT stations to a depth of 750 meters were scheduled midway between STD stations. This program was carried out except as noted below. The schematic track chart for TERITU operations in Phases 1 and 2 is attached as Figure B-16.

(2) From 17 to 19 August, personnel and mail were transported between FLIP/SANDS and Honolulu. XBT stations were taken at 30 nm intervals along the track during the period 17 to 22 August.

(3) Forty-seven STD and 76 XBT stations were made along the track between 22°N and 30°N. HISTD and BATHY messages for all stations were sent to FWC Pearl via HIG by teletype. All other data were delivered to FWC Pearl upon termination of the cruise.

(4) The cruise was terminated on 29 August as a result of repeated engine failures and badly contaminated fuel.

g. MIKIMIKI Operations in Phases 1, 2, and 3

(1) The PARKA Experiment Operation Plan scheduled MIKIMIKI to depart Oahu a few days before Phase 1 started in order to take eight deep velocimeter stations along the PARKA I track and arrive at about 43°N at about the same time as CONRAD. MIKIMIKI would then take velocimeter stations at 8 to 12 hour intervals at points about halfway between 43°N and CONRAD; CONRAD's SOA to be ten knots and MIKIMIKI's average SOA to be five knots. After the end of Phase 1 MIKIMIKI was to continue to take stations at this rate while returning to 43°N to meet RADFORD coming north in Phase 2. MIKIMIKI was then to take a similar series of deep velocimeter stations at points halfway between 43°N and RADFORD to the end of Phase 2, and then proceed to Kodiak for refueling. In Phase 3 she was to operate with CONRAD as scheduled and noted below. The schematic track chart for MIKIMIKI in Phases 1, 2, and 3 is shown in Figure B-17.

(2) Communications were interrupted several times by failure in the radios. Some BATHY and HISTD messages from Phase 3 could not be delivered by radio and were hand-delivered to FWC Pearl after arrival in port.

(3) After 17 August the maximum depth of the velocimeter probe was limited to about 4300 meters by the length of good cable remaining after a short circuit in the cable had been cleared.

(4) Thirty-six velocimeter and 54 XBT stations were made along the track during Phases 1 and 2. HISTD and BATHY messages for all these stations were transmitted by radio to the OCC Kaneohe.

(5) In Phase 3, the track south from Station 3A2 was along 157°43'W instead of the PARKA I track (157°50'W). From 30°N to 22°N stations were made at 15 nm intervals. HISTD and BATHY messages were made for all stations and were delivered by hand to FWC Pearl, along with all original data, after arrival in port.

(6) Copies of all data taken at acoustic stations 3A1, 3A2 and 3A3 during Phase 3 were delivered to NRL Personnel aboard CONRAD after arrival in port.

(7) A total of 55 deep velocimeter and 99 XBT stations were made.

(8) The time from 070900W to 092000W September was spent in port in Kodiak for logistics.

(9) The cruise commenced on 13 August 1968, and terminated on 24 September 1968, upon completion of all scheduled operations.

h. **Oceanographic Results**

As provided for in the PARKA I Experiment Operation Plan, the objective of TERITU and MIKIMIKI in Phases 1 and 2 was primarily to measure environmental conditions in support of the large scale acoustic exercise being conducted at that time. In addition, TERITU made three cruises during Phase 0, and MIKIMIKI participated in Phase 3 two-ship acoustic operations with CONRAD as directed by NRL. TERITU employed a Bissett-Berman STD probe to 1500 meters depth while MIKIMIKI employed a NUS velocimeter to great depths obtaining profiles of temperature and sound velocity. Both instruments measured depth as a function of pressure.

The above operations provided data from which isothermal, isohaline and isovelocity plots were made along the PARKA track from 22°N to 30°N for the months of May, June, July, and August 1968 and isothermal plots only for the month of September 1968. These plots are attached and are analyzed briefly below for the time-spatial changes in oceanographic conditions (Figure B-18 through B-29).

The most conspicuous feature is a strong thermal front or discontinuity which is present at about 28°15'N and which is also evident in the plots of salinity and sound speed. In general, this front is strongest above 200 meters, but exists as deep as 400 meters and is lost below that depth. A second feature generally evident is a dome at about 24°20'N. The features of the front and the dome vary from month to month in both their concentration and their location.

In May the thermal front is located at 28°15'N and the dome is at 24°20'N. The deeper isotherms of the thermal front after rising nearly vertically for about 50 meters break horizontally to the north, or dip slightly, to 28°50'N where they again rise nearly vertically for about 60 meters. Thus there are two thermal fronts, the strongest at about 100 meters at 28°15'N and a second weaker front at about 150 meters at 28°50'N

and a dome at 24°20'N. These features show clearly in the plots of salinity and sound speed.

In June there is a pronounced thermal front at 28°20'N with a nearly vertical rise of isotherms of about 120 meters. The May dome is not as distinct in June and has moved north to 25°N. There is a weaker thermal front at 25°50'N with a drop in isotherms of about 60 meters. These features show in the salinity and sound speed plots with the front at 28°20'N being the most conspicuous.

In July there is one concentrated thermal front at 28°30'N with a nearly vertical rise in isotherms of 150 meters and a pronounced dome at 25°20'N. These features are also clear in the isohaline and sound speed plots.

In August there is one distinct thermal front at 27°15'N with a rise in isotherms of 90 meters. The isotherms then dip slightly, reaching a low at 28°N after which they rise gradually to 30°N. There is a dome at 25°N. These features also are clear in the plots of salinity and sound speed.

In September the thermal front splits into two parts with the main gradient shallower and showing a rise in isotherms of about 110 meters at 26°30'N while the weaker second front is deeper and shows a rise in isotherms of about 50 meters at 28°15'N. Above 100 meters there is a suggestion of a dome at 24°30'N, but it has spread and lost its character. At depths below 100 meters, there is a dome at 25°30'N. Since the September data is from observations by MIKIMIKI there is no plot of salinity (Figure B-30).

In summary, the plots from May through September show two persisting environmental features which will markedly affect sound transmission in the shallow or surface layers. These features are a strong thermal front with rising isotherms at about 28°15'N and a dome at about 25°N. Although the period of observation has not been long enough to be conclusive, there is evidence that the thermal front builds toward a maximum concentration in July and August at 28°15'N and that it spreads and moves in September. There is also evidence that the dome moves northward from 24°20'N to about 25°20'N and becomes more pronounced from May through August. It then moves southward and starts to flatten out. It seems certain that the features of the thermal front at 28°15'N and the dome at 25°00'N change from month to month.

The fluctuations in thermal front location seems to result from the movements of water mass boundaries or from large scale turbulence known to prevail around the Hawaiian Island archipelago. The tongue of low salinity water intruding from the north at about 450 meters, as shown in the plots of salinity, seems to lend credence to the first supposition.

i. Digital Data Handling – Ship to Shore Via Teletype

During the PARKA I Experiment, the University of Hawaii's ship TERITU was not equipped with the special RF Communications transceivers installed on the other ships and so was unable to transmit observed STD data to the OCC Kaneohe via the Scientific Radio Network. Instead, TERITU STD and XBT data were compiled in HISTD or BATHY message format and were transmitted by teletype to the HIG Electronics Laboratory where they were picked up by messenger for hand delivery to FWC Pearl for retransmission to FNWC Monterey. The present teletype capability is described below.

HIG has been developing the capability to handle numerical data from ship to shore for some time. This effort stems from recognition

of the value inherent in being able to transmit raw oceanographic data on a real-time basis directly to the computer-supported scientific staff ashore, and the fact that such capability lies well within present technology. The development of this principle was in fact the underlying base upon which the operational details of the PARKA I Experiment rested.

Teletype equipment in use on both R/V MAHI and TERITU are light-duty, eight-level Teletype Model 33ASR and five-level Teletype Model 15KSA. During the PARKA I experiment TERITU used the regular HIG voice frequencies, for all teletype transmission. Because development funds have been scarce, fully automatic equipment has not been available and it was necessary for TERITU to call HIG by voice radio prior to teletype transmission in order to have HIG place the laboratory teletype in readiness on the line. Thus, the present teletype capability is limited to times when the HIG laboratory is manned, normally during regular working hours only.

Eight-level data is used either directly from eight-level recording equipment such as the Bissett-Berman STD or the NUS velocimeter or from messages such as the HISTD or BATHY formats hand-typed aboard ship.

Five-level data was used only on MAHI for communication of situation reports, science reports, equipment maintenance problems, and service requests. Five-level messages from shore to MAHI were used for data of an extensive nature, such as excerpts from maintenance manuals, numerical tables, etc.

During PARKA I, TERITU handled all BATHY and HISTD messages via printer. A daily run consisted of six to eight transmissions of each type of message. Transmission time for six of each type totals eight minutes. A second pass was frequently made for error corrections or for assurance of good copy. An eight minute run amounts to about 3,000 characters. Voice handling of 3,000 characters would take about an hour, would require retyping in Honolulu, and would have a high error rate.

The present teletype error rate is believed to be better than that obtained by single voice transmission. When the ships are within 1,000 miles of Honolulu, it is usually necessary to transmit the data only once. A second transmission is used when errors are noted. More than three transmissions have never been required. The eight-level format is such that errors in a single bit result in a non-printing character or letter. The standard messages contain enough redundancy and regularity of block length that many errors are immediately apparent, either by eye or by computer. Radio transmission and the synchronization of machine-sent teletype cause most errors to be spread over more than one character, destroying block length. The combination of these factors results in a surprising amount of assurance that the data received is either good or bad. Use of a third transmission and best-two-out-of-three methods are seldom necessary. Present error rate is estimated at one bad five-character block per thousand characters.

Diversity reception (the use of two antennas, two receivers, and decision-making electronics to choose the best signal for each bit) and the use of commercial equipment should improve the error rate by a factor of five to ten. Replacement of inferior equipment would greatly reduce maintenance problems. Use of fully-automatic equipment would provide full-time coverage.

For post PARKA I work, HIG will use new Teletype Model 35 ASR equipment.

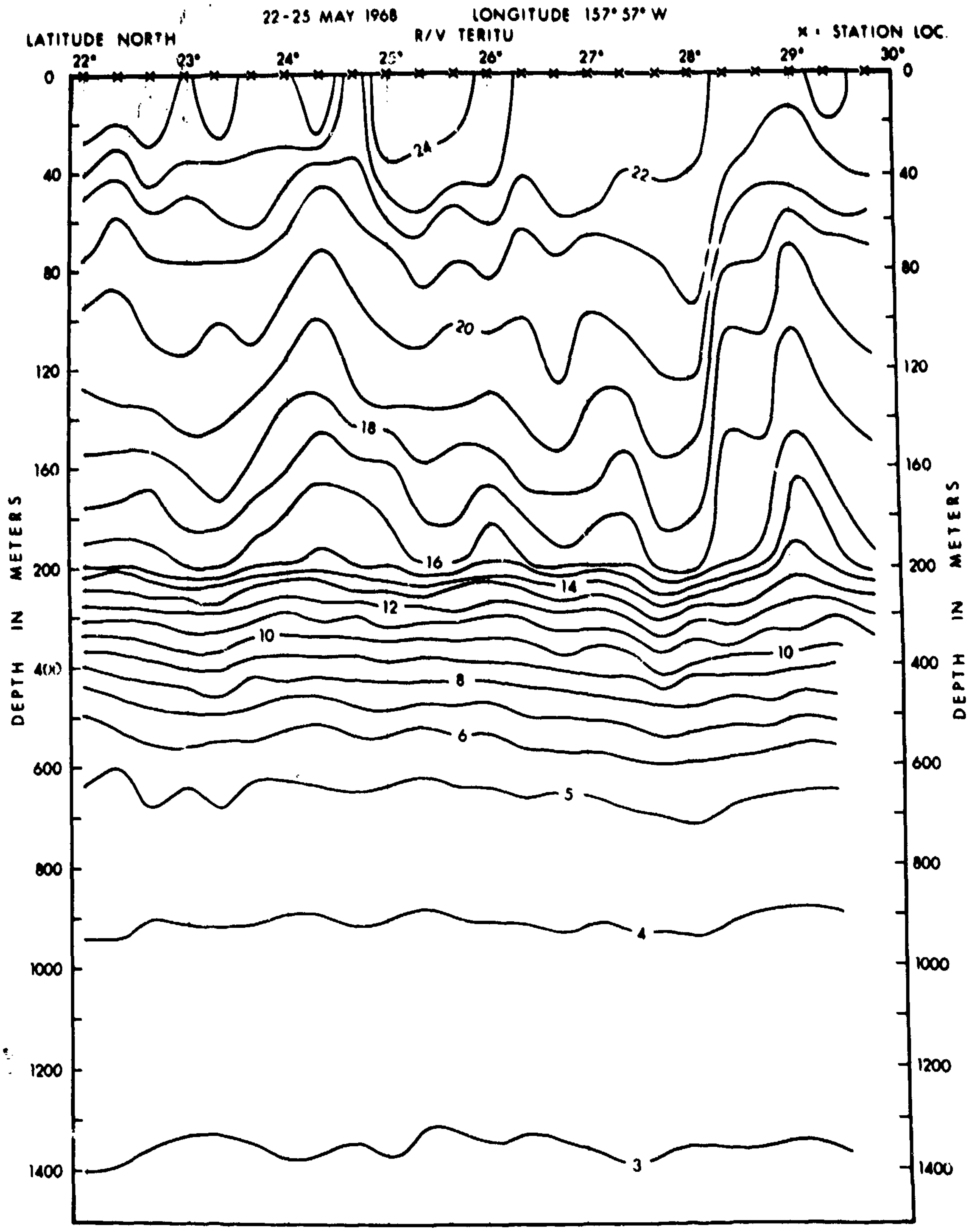

Fig. B-18 – PARKA Phase 0, Run 1, Temperature – °C (U)

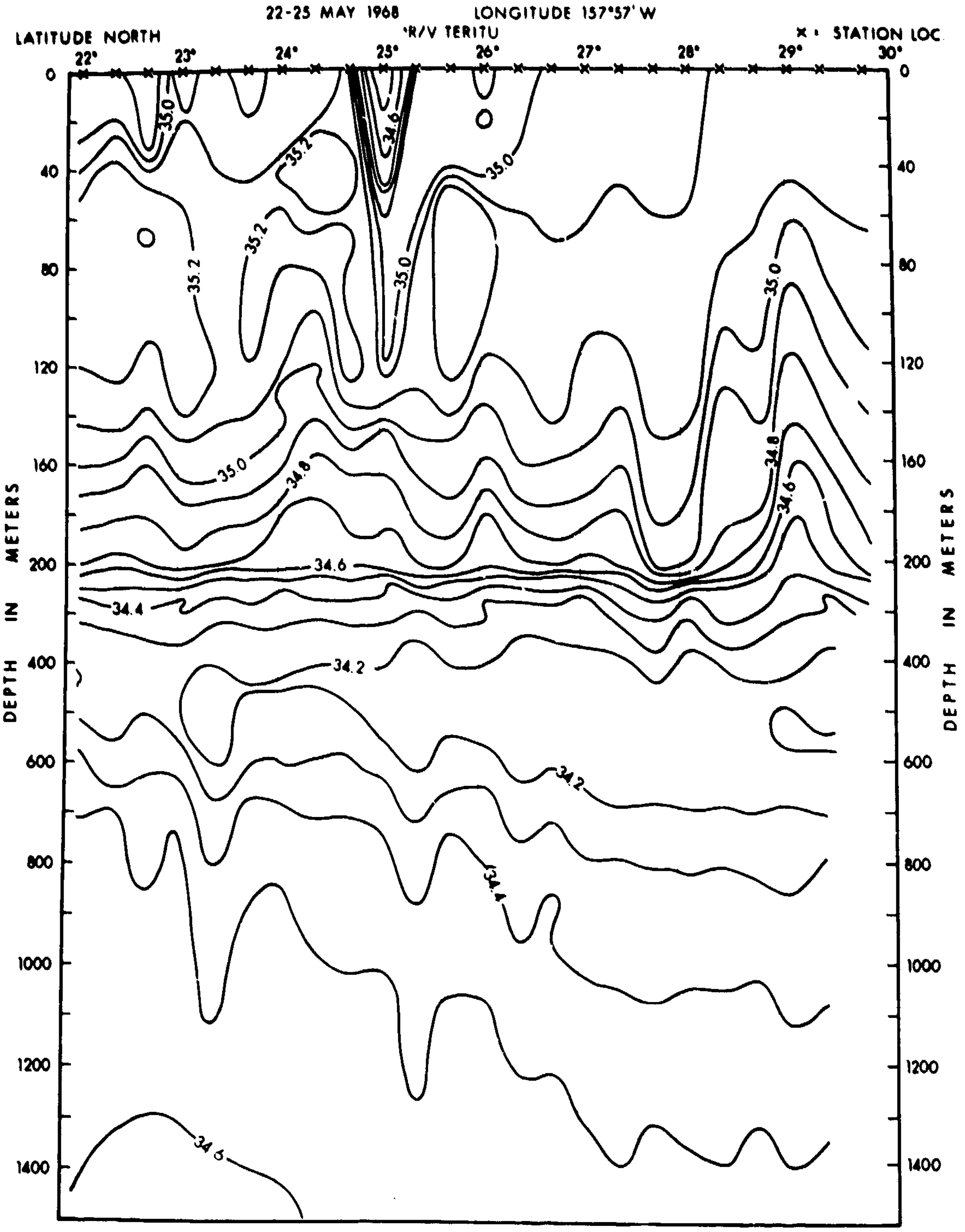

Fig. B-19 — PARKA Phase 0, Run 1, Salinity — °/∞(U)

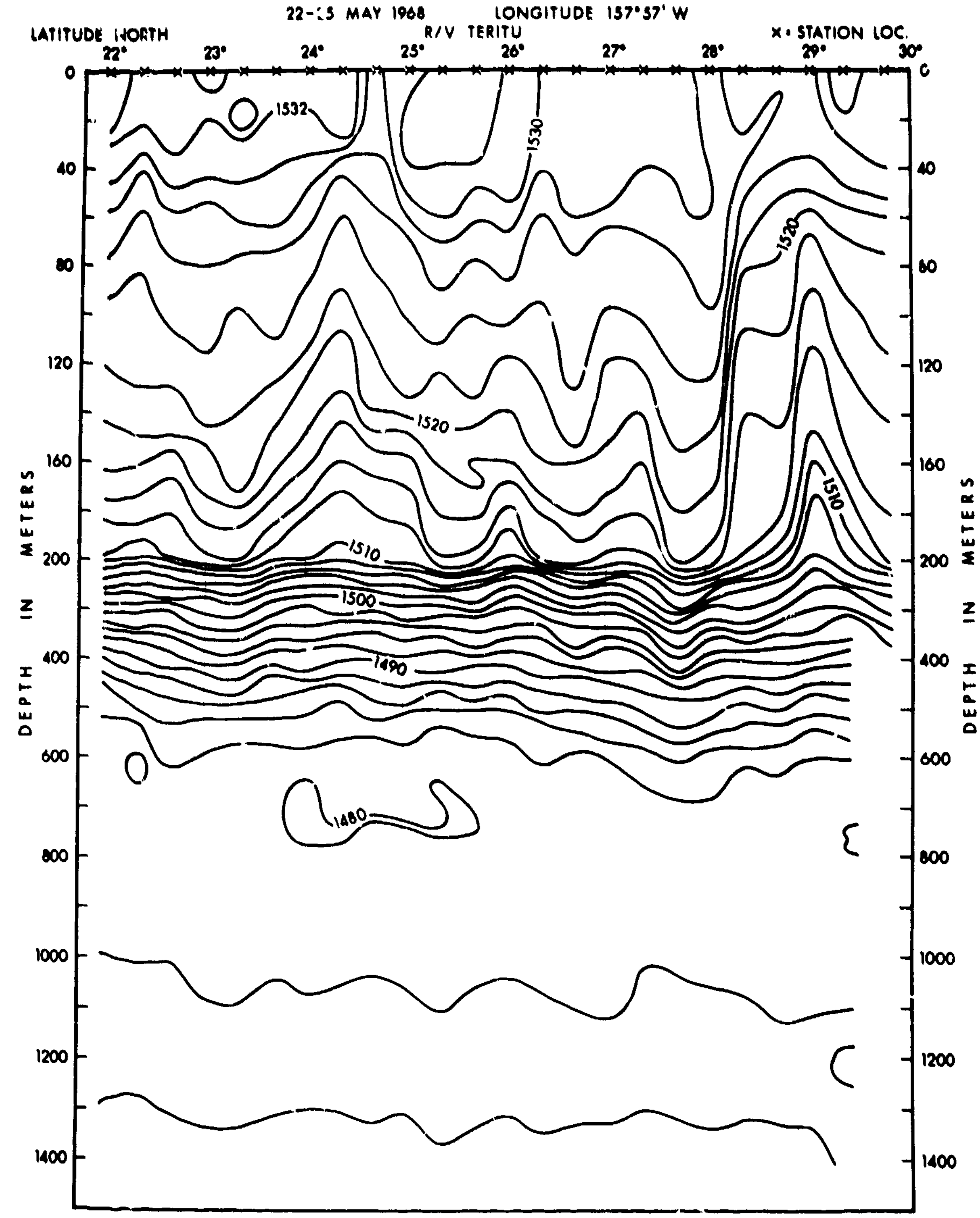

Fig. B-20 – PARKA Phase 0, Run 1, Sound Speed – m/sec (U)

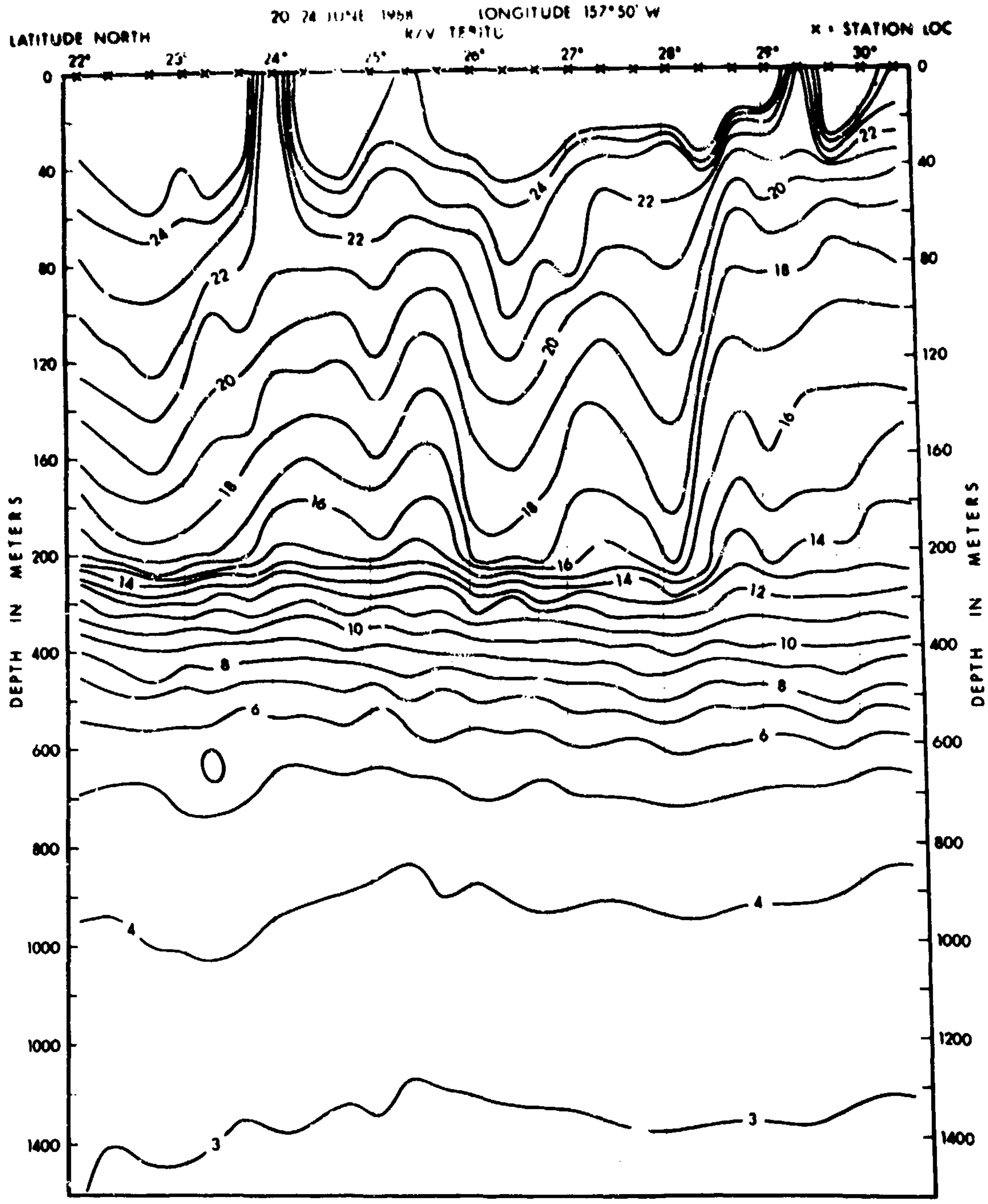

Fig. B-21 – PARKA Phase 0, Run 2, Temperature – °C (U)

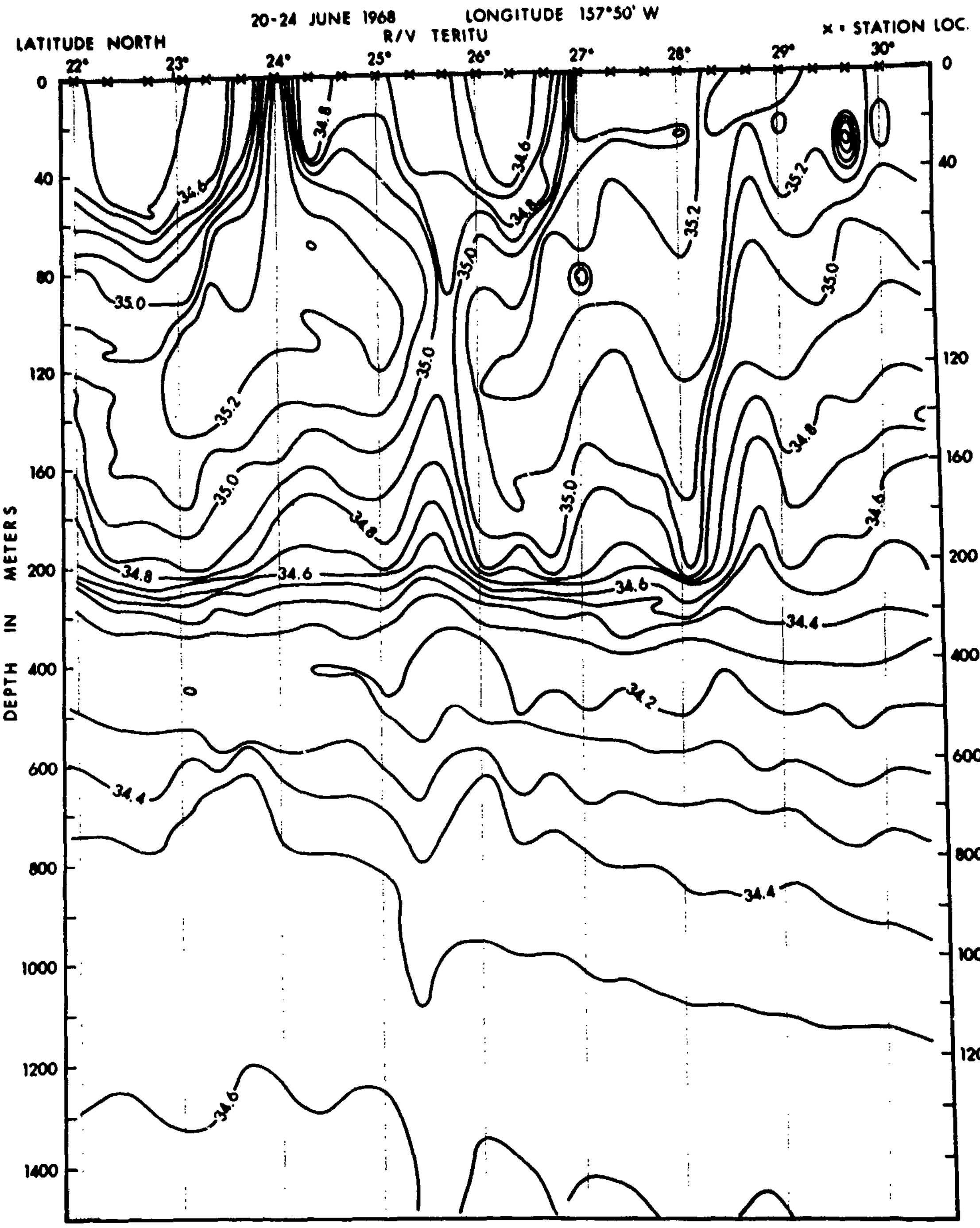

Fig. B-22 – PARKA Phase 0, Run 2, Salinity – °/∞(U)

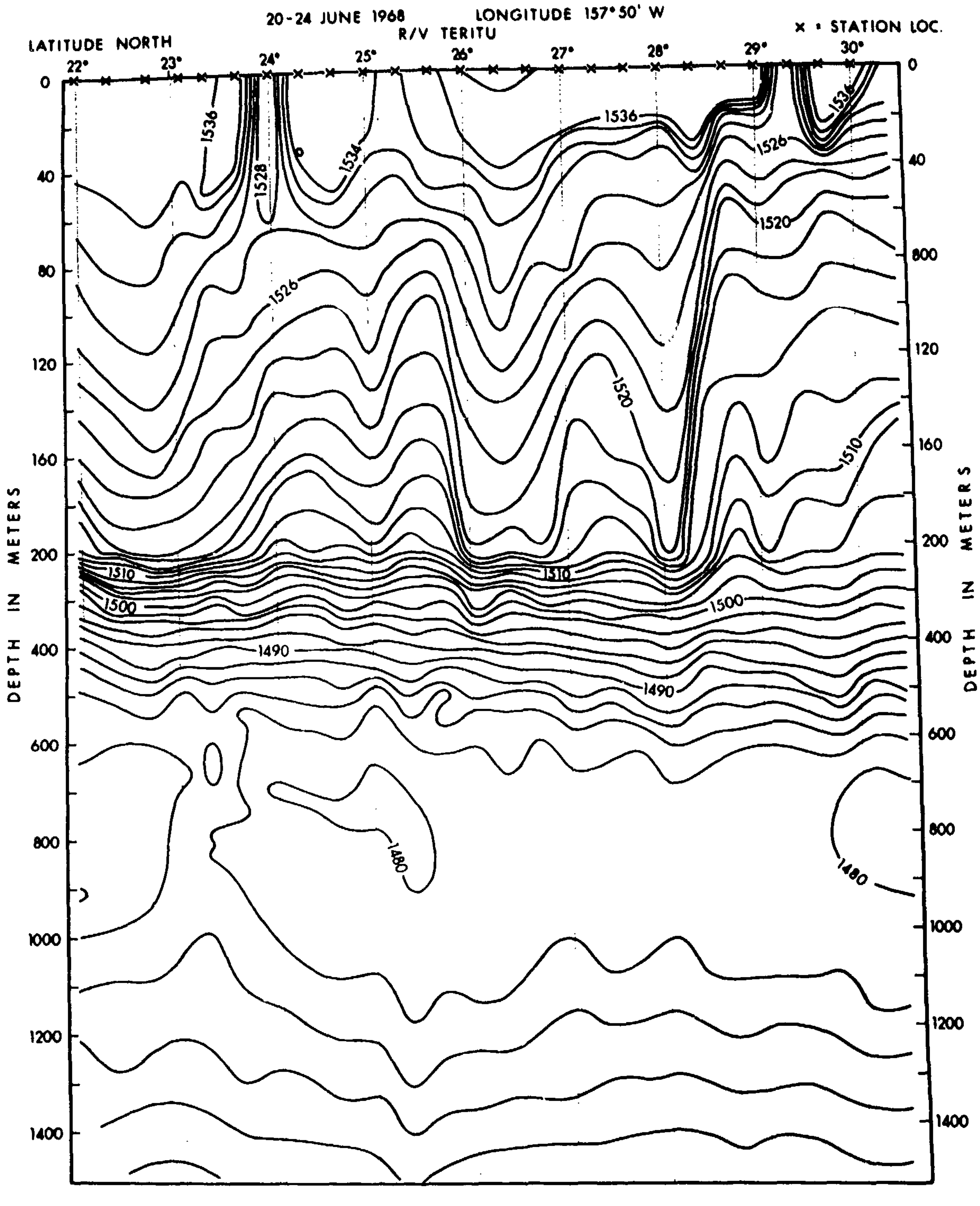

Fig. B-23 – PARKA Phase 0, Run 2, Sound Speed – m/sec (U)

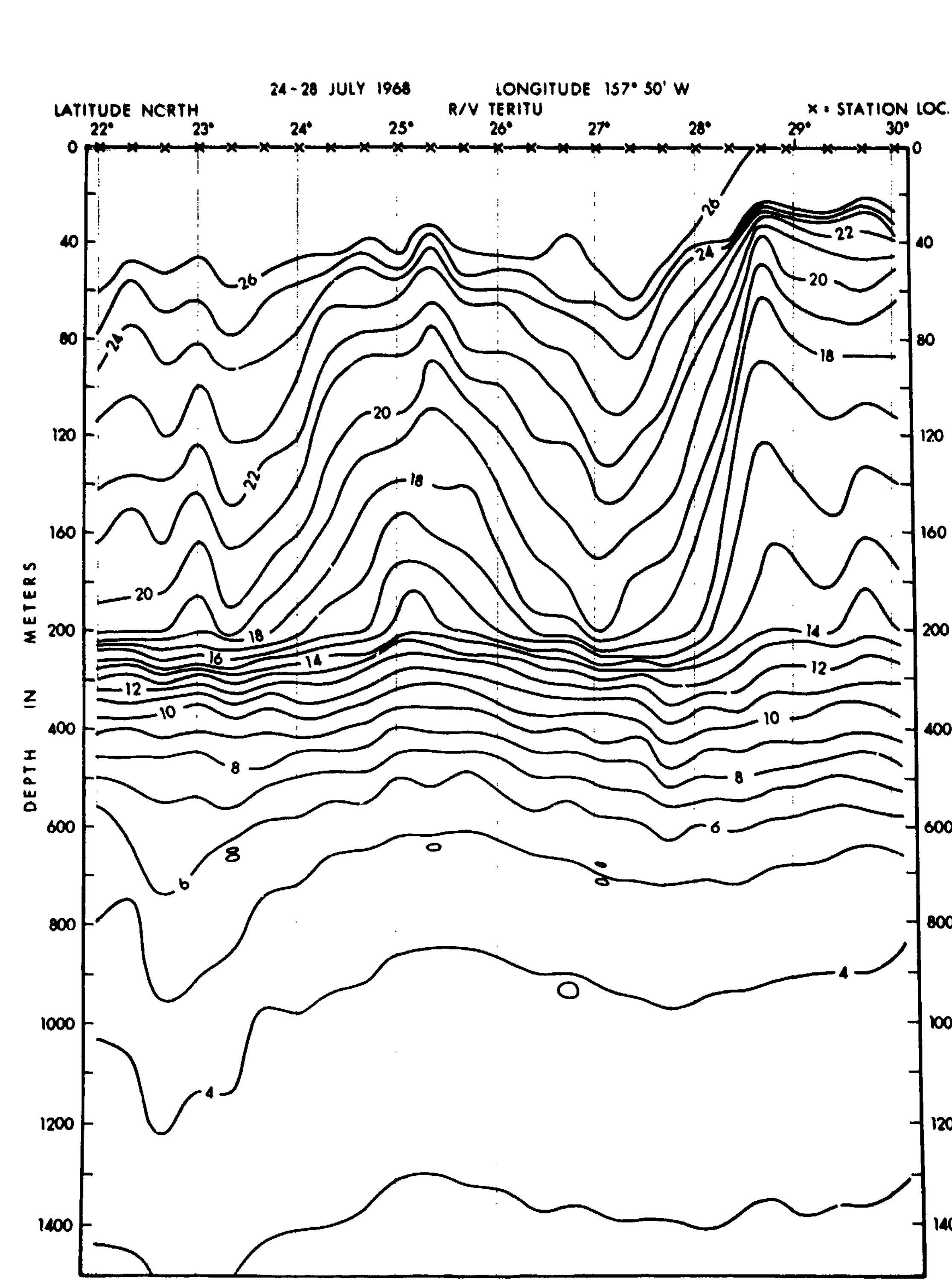

Fig. B-24 – PARKA Phase 0, Run 3-R, Temperature – °C (U)

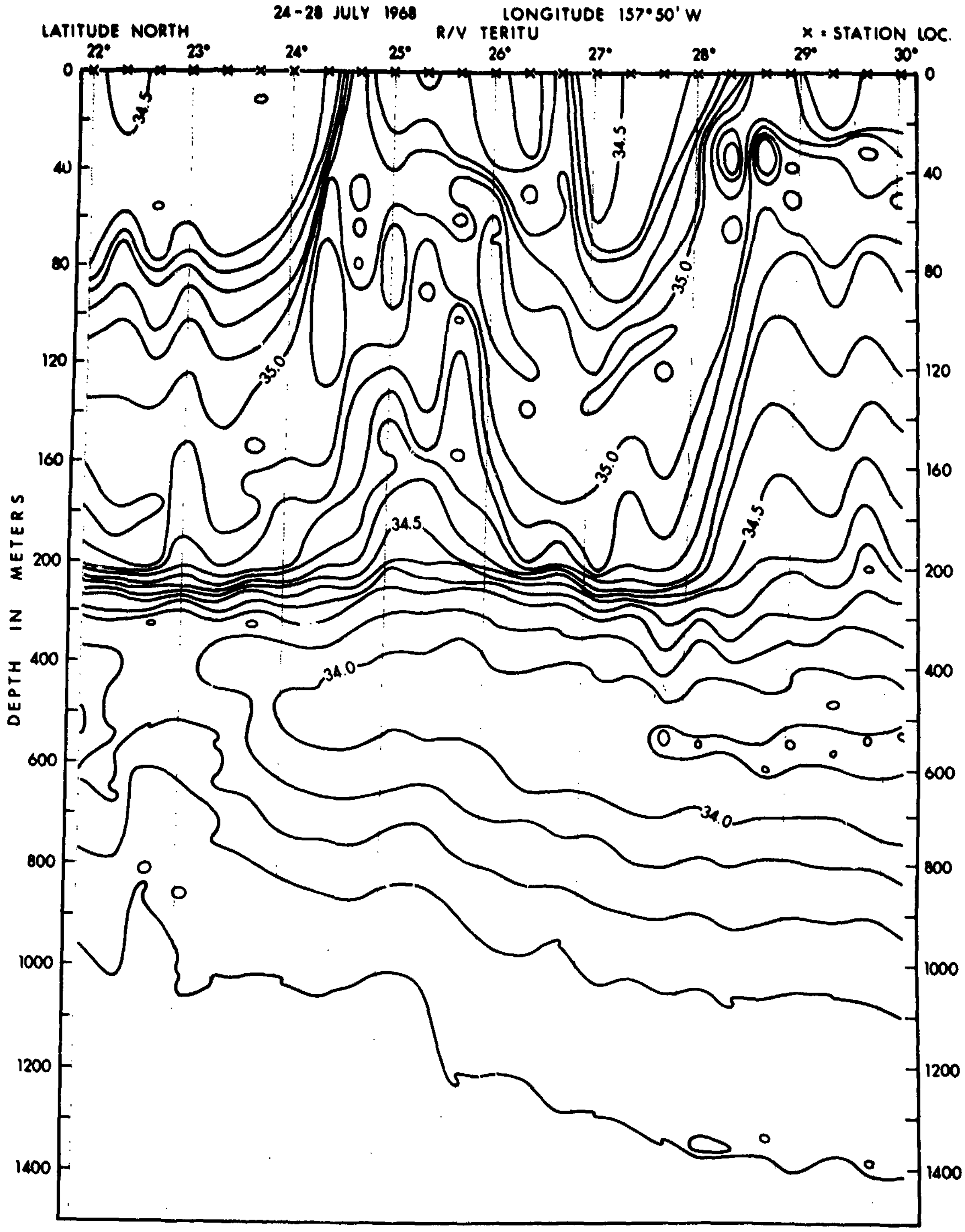

Fig. B-25 – PARKA Phase 0, Run 3-R, Salinity – °/∞ (U)

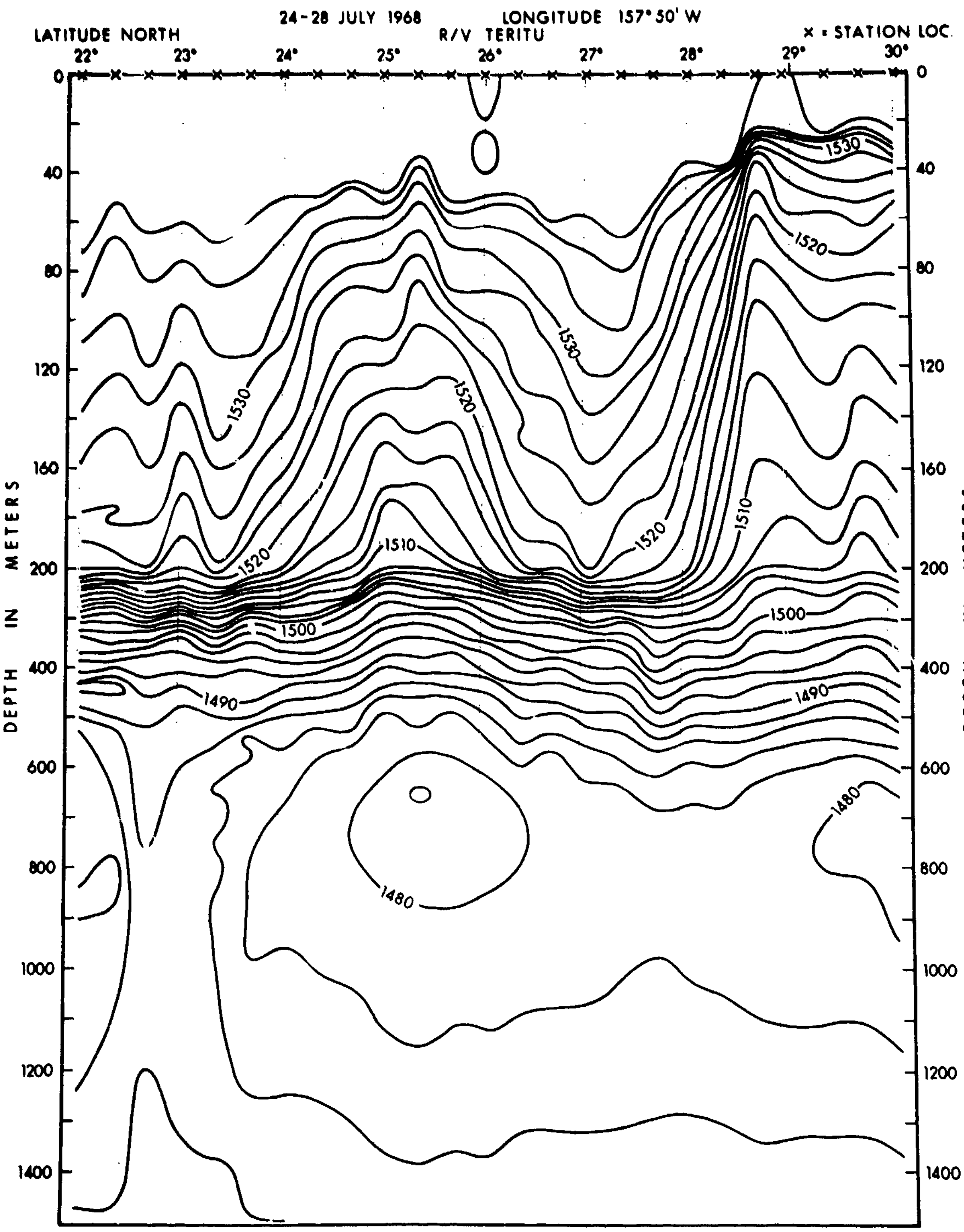

Fig. B-26 – PARKA Phase 0, Run 3-R, Sound Speed – m/sec (U)

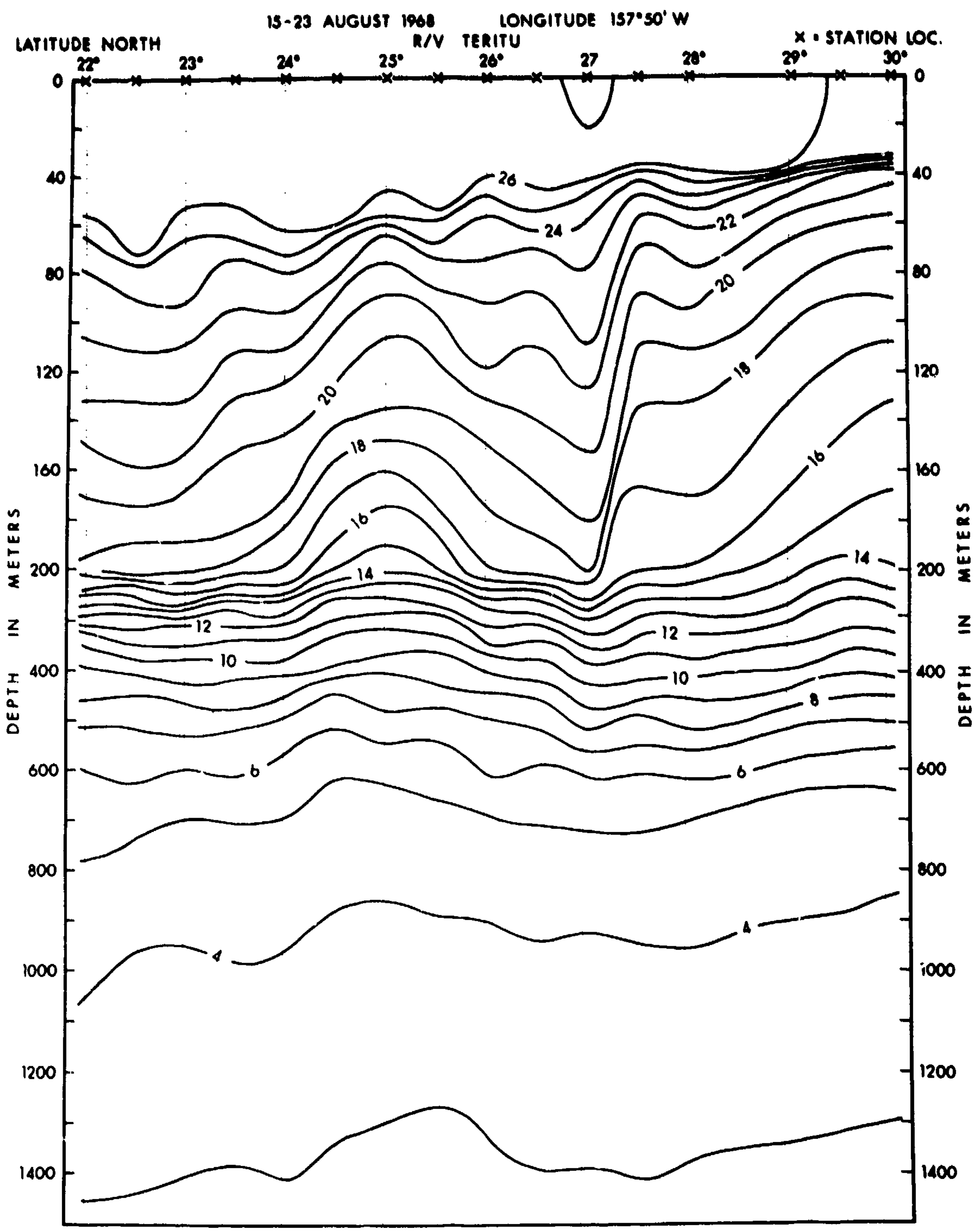

Fig. B-27 – PARKA Phase 1, Temperature – °C (U)

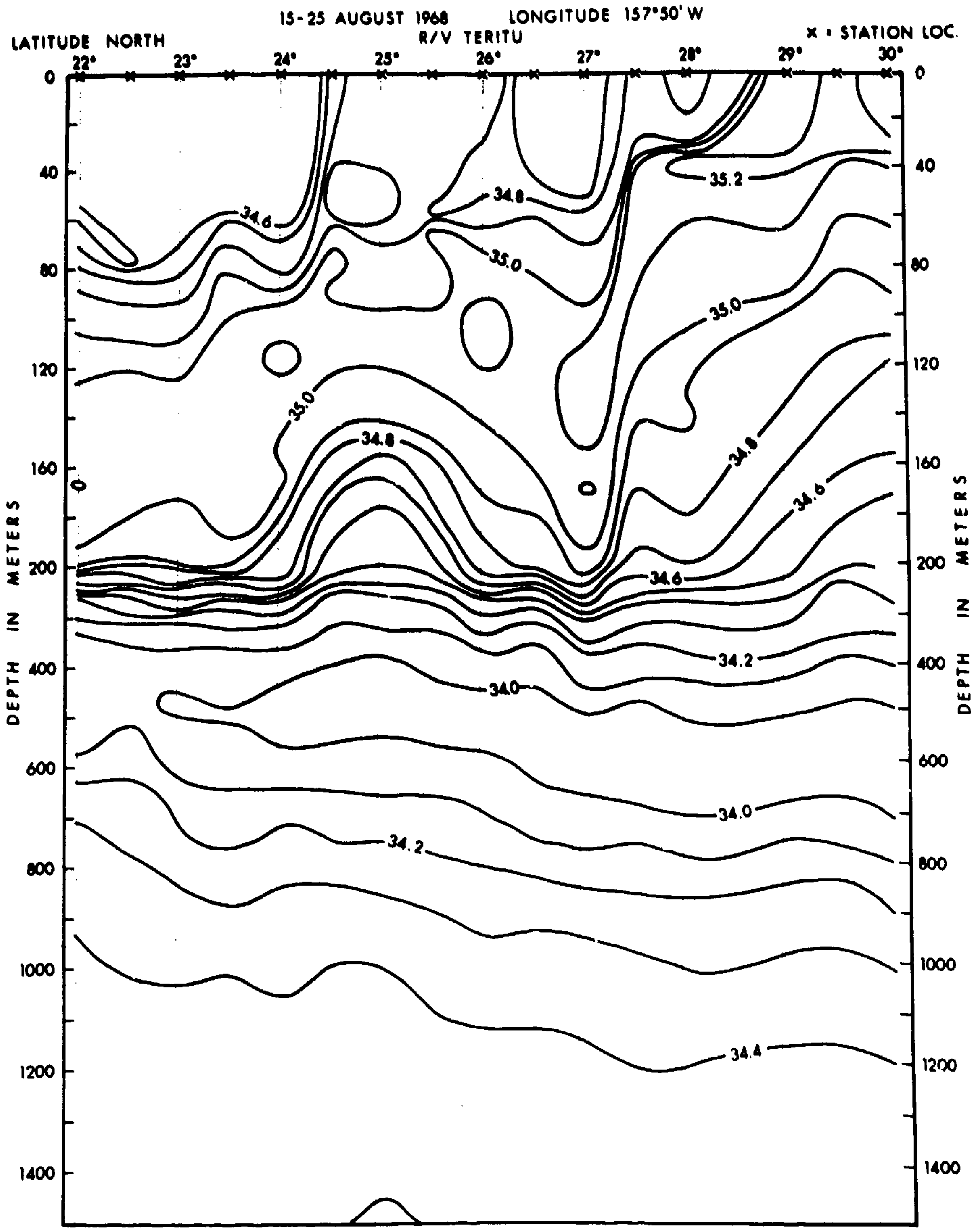

Figure B-28 – PARKA Phase 1, Salinity – ‰ (U)

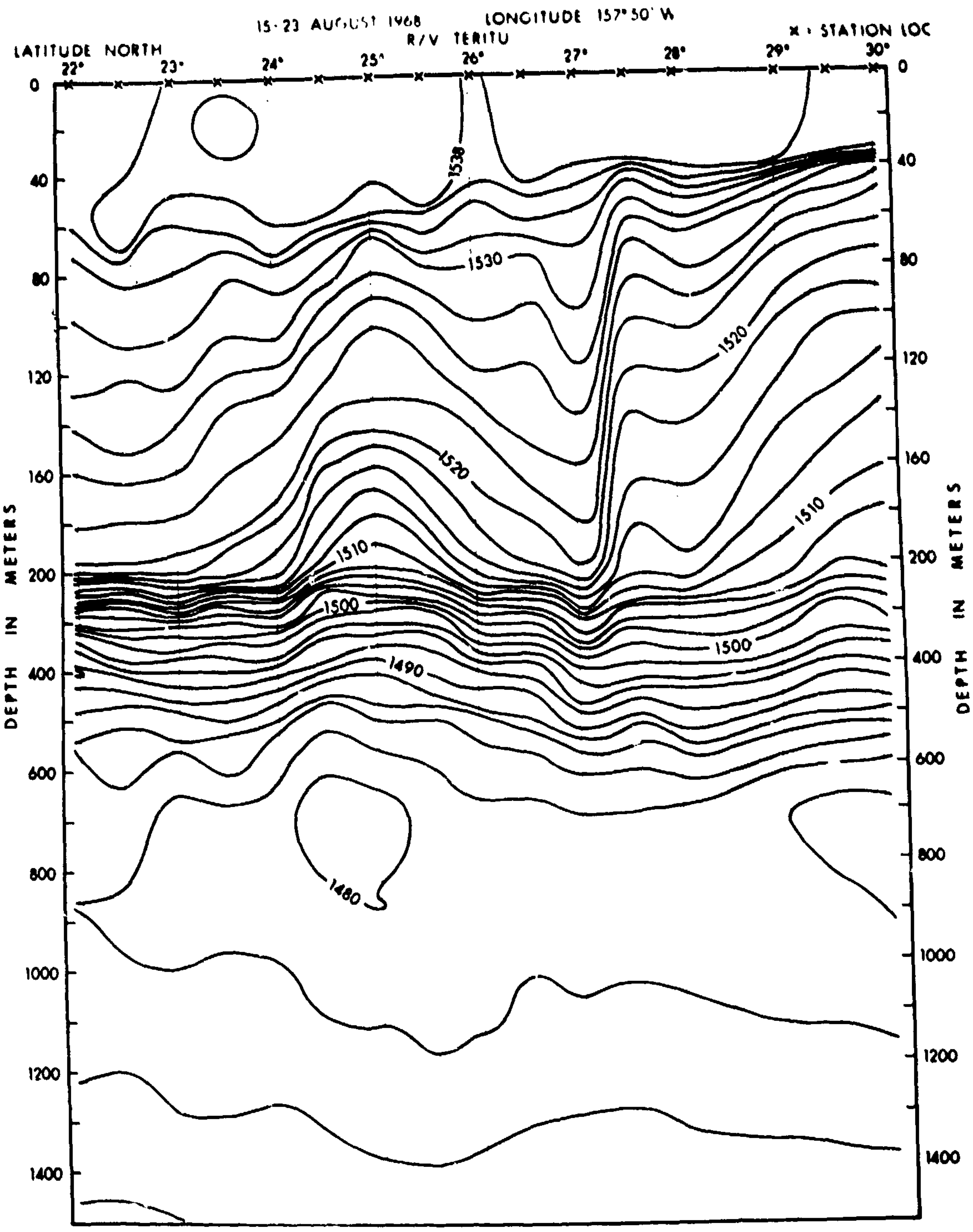

Fig. B-29 – PARKA Phase 1, Sound Speed – m/sec (U)

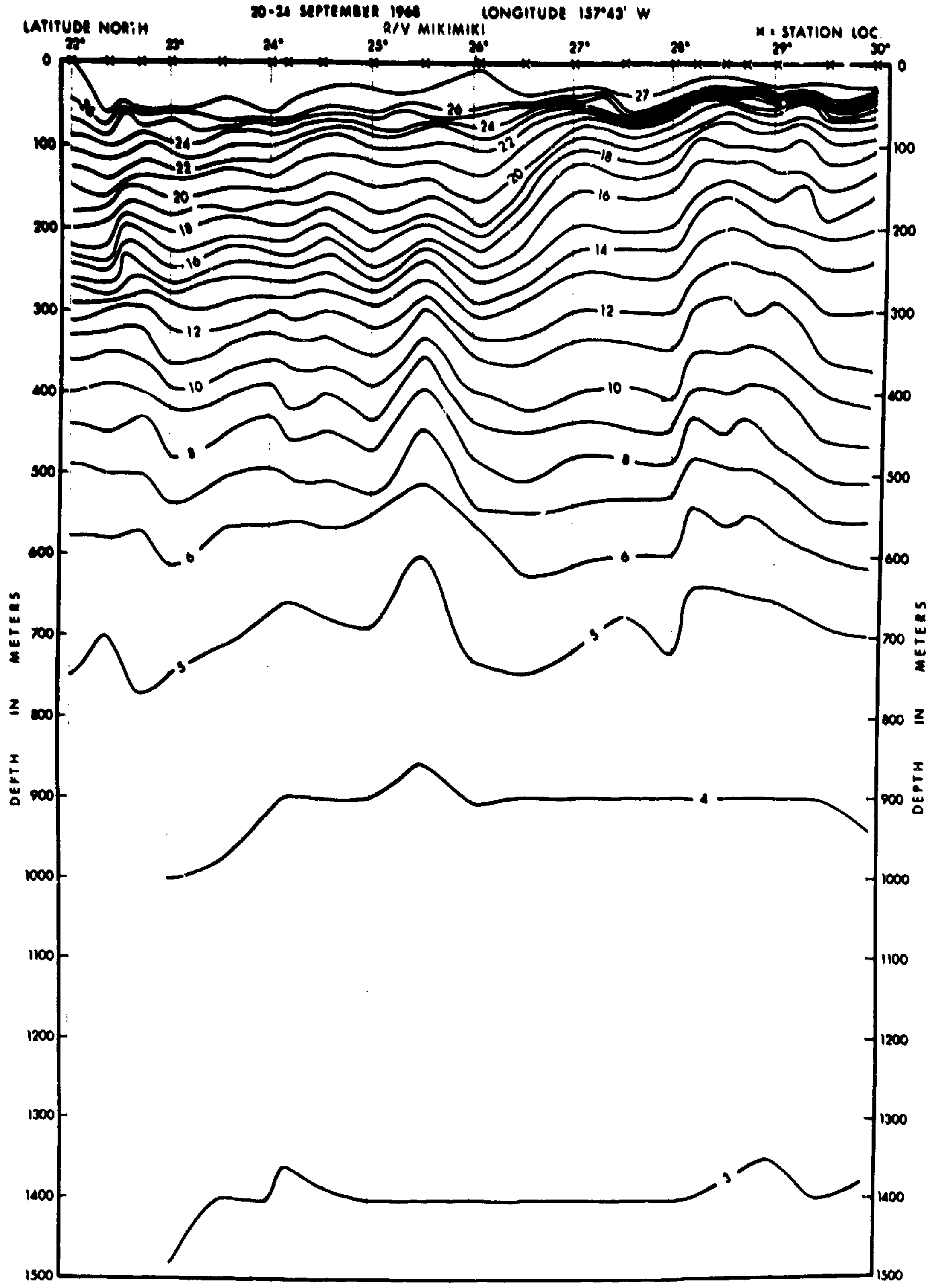

Fig. B-30 – PARKA Phase 3, Temperature – °C (U)

11. WHOI Oceanographic Operations

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a. Objectives

The principal objective of the Woods Hole Oceanographic Institution's (WHOI) role in the PARKA I Experiment was to measure and record the sound velocity as a function of depth in the ocean at selected points along the PARKA I track. A sufficient number of points to adequately define each profile was transmitted by radio to FWC Pearl to aid in the prediction of sound propagation along this track. A secondary objective was the collection of temperature and pressure data as a functions of depth, all of which data were collected with a new oceanographic data collection system developed at WHOI in conjunction with the Sylvania Electronic Products Company.

b. Equipment

The in-water package contains: (1) a WHOI-built Inverted Echo Sounder (IES) (Dow, Stillman, 1962) and its associated 12 kHz transducer; (2) and NUS Corporation TR-4 sound velocimeter; (3) a Hytech model 4005 temperature sensor; (4) a Hytech model 4006 pressure sensor; (5) a sensor time-multiplexing unit built by Sylvania; (6) associated batteries to power all of the above; and (7) a frame to support and protect all of the instruments. The package measures about 24 inches by 30 inches by 62 inches and weighs 400 pounds in air.

This package was linked to the ship both electrically and mechanically by an armored, coaxial cable and its associated winch. Slip rings on the winch connected the upcoming signals to the signal processing and recording equipment. The principal components of this processing system can be seen in Figure B-31.

c. Theory of Operation

The sensor signals coming up the cable from the package are time separated from each other, and the IES signal is frequency separated from these sensor signals. The IES is "inverted" in the sense that the transducer is on the top of the package directed toward the ocean surface. An IES-transmitted acoustic pulse at 12 kHz travels to the surface where it is reflected back down to be received and amplified in the receiver portion of the IES. The travel time for this pulse to reach the surface is directly related to the depth of the package, and inversely related to the speed of sound in the water column above the package. This travel time is measured and recorded. Now all that needs to be known in order to accurately determine the depth of the package is the speed of sound in that column. This unknown is continuously measured during the lowering with a sound velocimeter, and one thus has all the information necessary to compute the depth of the package according to the following relation:

$$d_N = \sum_{i=1}^{N} \overline{V}_i \frac{(t_i - t_{i-1})}{2}$$

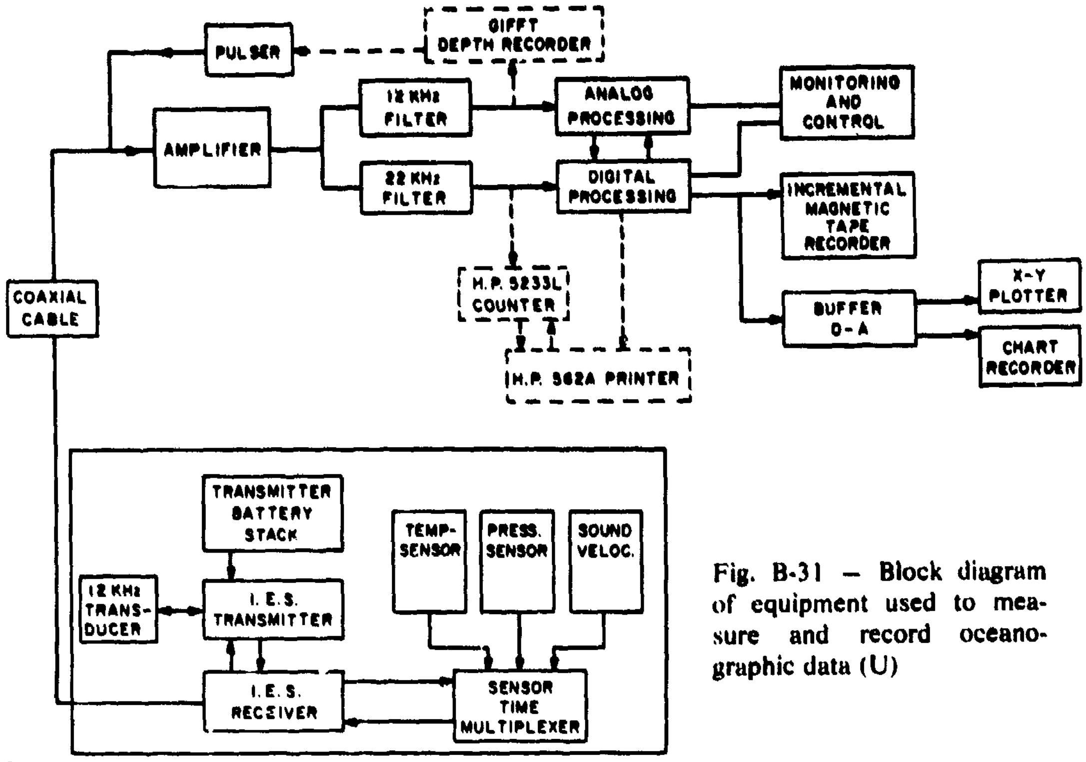

Fig. B-31 – Block diagram of equipment used to measure and record oceanographic data (U)

with d_N the depth at point N, $\overline{V}_i$ the sound velocity in the ith interval, and $(t_i - t_{i-1})$ the difference in travel time of the IES acoustic signals between successive depths. (The one-half factor is inserted in the above equation because, although the travel time of the acoustic signal from the package to the ocean surface is the quantity of interest, in practice the round trip travel time from the package to the surface and back to the package is the quantity measured and recorded).

A "system cycle" lasts for two seconds, during which time the IES transmits once, one IES return is received, and each of the sensors in turn is measured and recorded. (The present system contains three sensors; a velocimeter and a temperature and pressure sensor but the system is capable of handling up to eight sensors with an FM output). The cycle starts with the firing of the IES transmitter upon a pulse command from the surface. Since the IES signal is at 12 kHz and may come up the cable anytime during the two second cycle, the sensor signals are multiplied by an appropriate factor in the multiplexer unit in order to put them in the 19.5 to 24.5 kHz region. This frequency separation allows the sensor signals and IES signals to be separated from each other by filters at the surface.

The sensor signals in contrast to the IES signal are frequency modulated. Each sensor's period is averaged over a predetermined number of cycles and this information is digitized and sent to an incremental magnetic tape recorder where it is stored on magnetic tape.

The measurement of the IES signal travel times is somewhat more complex due principally to the fact that spurious signals could be misinterpreted as true IES returns by the digital circuitry were it not for elaborate signal detection methods. It is sufficient to say that these

travel times are digitized and stored on magnetic tape along with the sensor signals.

The incremental magnetic tape recorder is the primary recording medium for the system; however, there is an x-y plotter which can plot the sound velocity as a function of pressure/depth in real time. The degree of accuracy here is considerably less than that obtainable from the digital information stored on magnetic tape and serves only as a rough check on the data to the tape recorder. A set of monitoring lights on the front panel allows one to check the digitized data for the sensors more accurately, but this more accurate data is not continuously plotted automatically.

During the PARKA I cruise, in addition to the above mentioned recorders, two auxiliary recording means were used (shown as dashed line blocks in Figure B-31); one for the IES data, and one for the sensor data. The IES data was recorded on a Gifft Depth Recorder (GDR) and the sensors' period average was measured with an electronic counter and printed out in decimal form on paper tape.

d. Operations

Phase 2 of PARKA I took place between 27 August and 5 September 1968. During this period WHOI – PARKA I SVP numbers 1 through 21 were made along the PARKA I track between Hawaii and Alaska. Figure B-32 shows the SVP number, position, date, and beginning times of each of these lowerings. These were the measurements of principal interest, but XBT drops were also made. XBT's were dropped at each of the SVP stations immediately prior to or immediately after a lowering, and an XBT was dropped approximately midway between each of these stations. The USS MARYSVILLE (PCER 857)

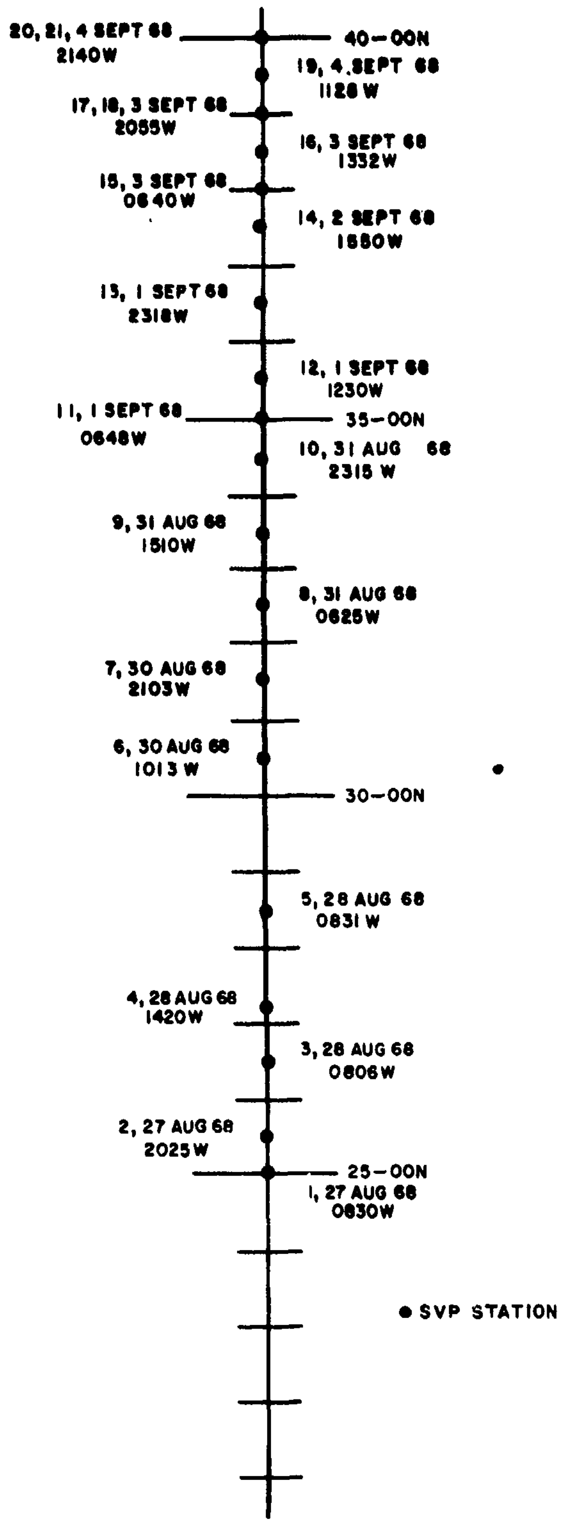

Fig. B-32 -- SVP number, position, date, and beginning times (time zone W) of each MARYSVILLE station (U)

was the platform for these oceanographic measurements.

e. Processing Procedures for Transmitted Data

A nearly complete computer program has been written for a Hewlett-Packard 2116A computer to extract and process the data stored on the digital magnetic tape of this new system. However, since a computer was not available on board MARYSVILLE to process the data, manual computations were made on the IES and sound velocity data in order to generate a sound velocity profile. This sound velocity profile was computed immediately after each lowering with the aid of a desk calculator. It was computed on the basis of the "down" data only. A sound velocity profile could have been generated more quickly and easily using pressure sensor data for the depth, but it was deemed important to realize the maximum accuracy possible under the circumstances; therefore, the calculation of the IES velocimeter SVP for the PARKA I experiment.

The IES travel time data was extracted from the GDR record visually with the aid of a scale. Referring to Figure B-33, the form used for these calculations, these travel times were listed in the column headed TT/2, the one way travel time for the IES signal. $\Delta TT/2$ is the difference in one way travel times between successive depths of the package and is equal to

$$\left(\frac{TT_i}{2} - \frac{TT_{i-1}}{2}\right).$$

The period average of 1000 cycles of the velocimeter signal was measured on a Hewlett-Packard model 5233L electronic counter and printed out in decimal form on paper tape by a Hewlett-Packard 562A printer. These period data were then converted to sound velocities with the aid of tables applicable to that particular velocimeter based upon its calibration constants.

The GDR data and the printed velocimeter data were time correlated and the appropriate velocities were listed in column 3 of Figure B-33.

The mean of the sound velocities at successive depths was next calculated according to

$$\overline{V}_i = \left(\frac{V_i + V_{i-1}}{2}\right)$$

and these values were listed in column 4 of Figure B-33. This value of $\overline{V}_i$ is the same as the sound velocity average in the interval if the sound velocity gradient is constant in this interval. Where the velocity gradient was changing rapidly points were taken close together; where the velocity gradient was fairly constant points were chosen farther apart.

The fifth column of Figure B-33 is the product of $(\Delta TT_i/2)$ and $\overline{V}_i$ which gives the incremental depth between successive data points, and the sixth column is the sum of these incremental depths. Columns 3 and 6 are thus the data points along the SVP. These data points were plotted on graph paper and a smooth curve was drawn between them. Those 30 to 50 points which best described this particular profile were then picked off of this curve and radioed to FWC Pearl.

f. Accuracy of Results

The velocimeters used were of the Model TR4 "sing around" type. These instruments are capable of very precise relative measurements but to obtain absolute data from them they must be calibrated. Prior to PARKA I the two velocimeters used were calibrated at WHOI in a distilled water bath whose temperature was controlled to ±.01 degrees C. About 60 data points were taken, ranging from

PARKA EXERCISE
FORM FOR CALCULATIONS, SVP WITH I.E.S., S.V. DATA

$$\text{USING } d_n = \sum_{i=1}^{n} (\overline{V}_i)\left(\frac{\Delta TT_i}{2}\right)$$

LOWERING NO. ____________

i	$\frac{TT}{2}$ (sec)	$\frac{\Delta TT}{2}$ (sec)	V (meters/sec)	$\overline{V}$ (M/sec) $= (V_i + V_{i-1})/2$	$\left(\frac{\Delta TT}{2}\right) \times \overline{V}_i$	$dn = \sum_{i=1}^{n} \left(\frac{\Delta TT_i}{2}\right) \times (\overline{V}_i)$ (meters)
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						

Fig. B-33 – Form for calculating IES depth (U)

close to zero up to 50 degrees C, corresponding to sound velocities of about 1410 meters per second and 1543 meters per second, respectively. Though the speed of sound in distilled water at low temperatures is very low in comparison to that in oceanic waters, it is thought wise to calibrate to these low temperatures to serve as a check on the performance of the velocimeters at low temperatures such as are encountered in the oceans. A least squares fit by a computer program then related the frequency of the velocimeter's output signal to the speed of sound based upon Greenspan and Tschiegg's (1957) relationship between the temperature and the speed of sound in distilled water. In neither case did any data point vary as much as 0.03 meters per second from these best fit straight lines, and the standard deviation of all points for each was about 0.015 meters per second. The absolute accuracies of the sound velocities measured in the ocean with these velocimeters is, however, lower than is implied above, principally because the absolute accuracy of the measured speed of sound in distilled water as a function of temperature is open to question. Several independent investigations of this relationship, though internally consistent, vary from each other by as much as 0.3 meters per second. In addition, the temperatures and pressures encountered in the ocean may affect the sound path length and thus the accuracy of these velocimeters to a significant degree. Based upon the total available information, however, we assign an absolute accuracy of ±0.3 meters per second for our velocimeter-measured sound velocity data.

The IES itself is not particularly subject to calibration errors, but rather, the accuracy of the IES data depended principally upon the resolution of the GDR for the particular sweep used. These data were recorded with the GDR on a one-second sweep speed and the one way travel time could generally be extracted to the nearest millisecond. However, near the surface (0 to 20 meters) these data could have been in error by as much as 2 milliseconds. Assuming for the moment an average sound velocity in the water column above the package of 1500 meters per second, the depth error due to this travel time inaccuracy could amount to ±3 meters near the surface, and ±1.5 meters at all other depths. Another possible source of error in the depth calculation is due to the fact that not every recorded data point was used in this calculation (actually only about one point in 60 was used) and therefore the true *average* sound velocity in any increment varied somewhat from the calculated *mean* sound velocity in the interval. This difference amounted to probably not more than ±0.5 meters per second. This error is algebraically additive and could amount to a maximum of about 2 meters at a depth of 6000 meters and correspondingly less at lesser depths. We assign an overall error to the radio-transmitted data of about ±0.3 meters per second for the sound velocities and a maximum of about ±4 meters for the depth data at the greatest depths encountered. Most of the sound velocity profiles were run to a maximum depth of about 2000 meters, and for these profiles the depth error probably does not exceed ±2 or 3 meters.

WHOI – PARKA I SVP's numbered 1 through 16 and 18 through 21 are plotted as Figures B-34 through B-53. SVP 17 was a shallow station and has been deleted. Numerous problems were encountered with the winch on board MARYSVILLE with a resultant loss of cable, and a consequent maximum depth capability of roughly 2000 meters. Therefore, although several of the lower numbered SVP's go to greater depths, each SVP is plotted to a maximum depth of 2000 meters.

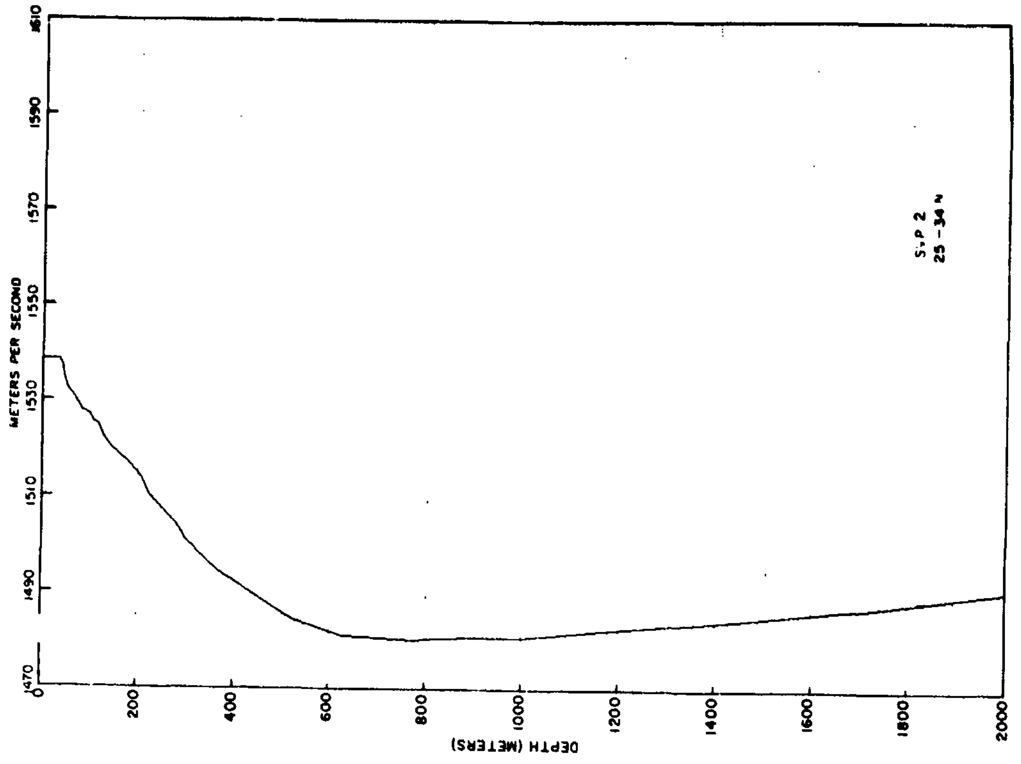

Fig. B-35 – Sound velocity profile 2 (U)

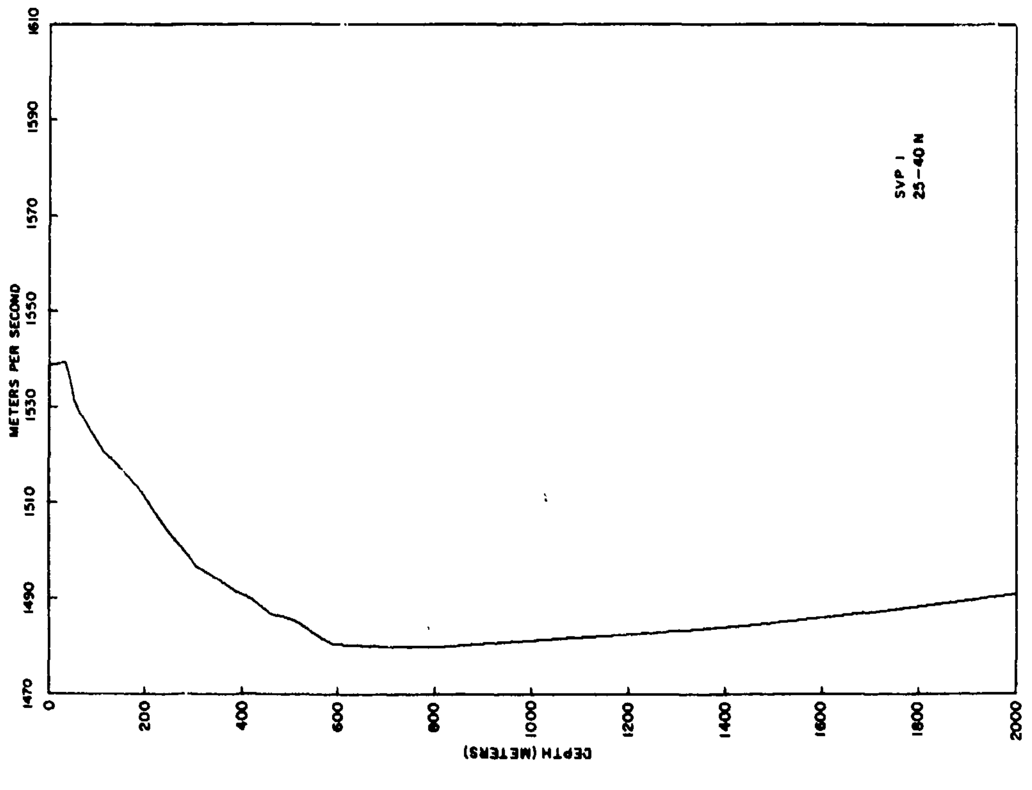

Fig. B-34 – Sound velocity profile 1 (U)

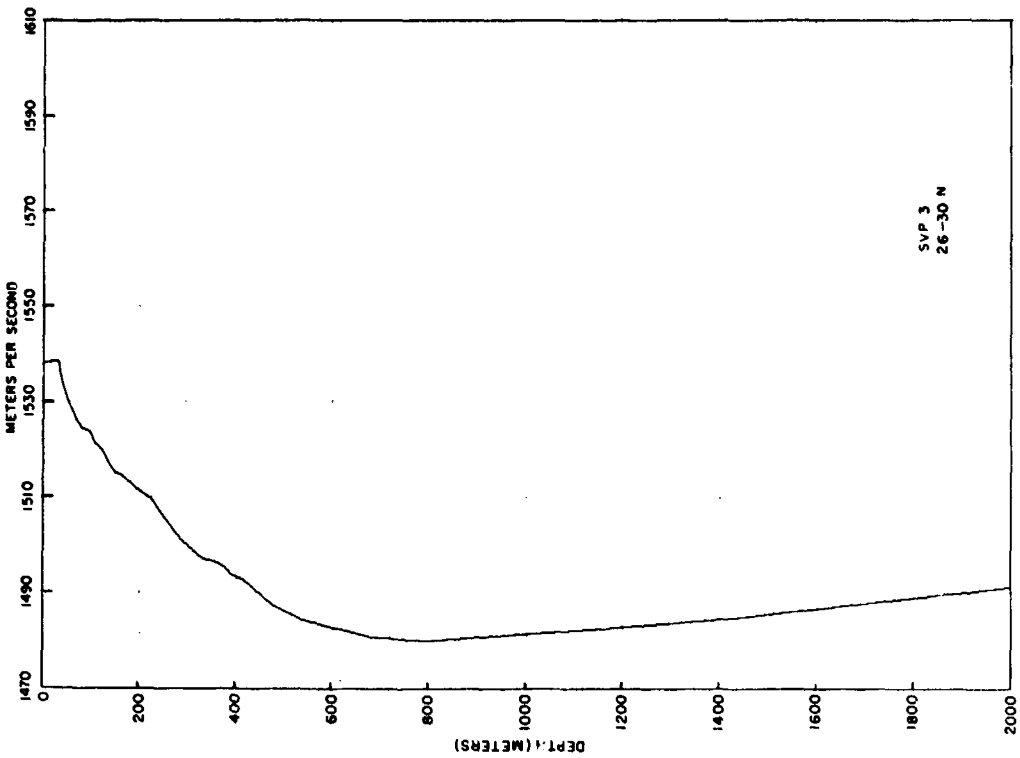

Fig. B 36 – Sound velocity profile 3 (U)

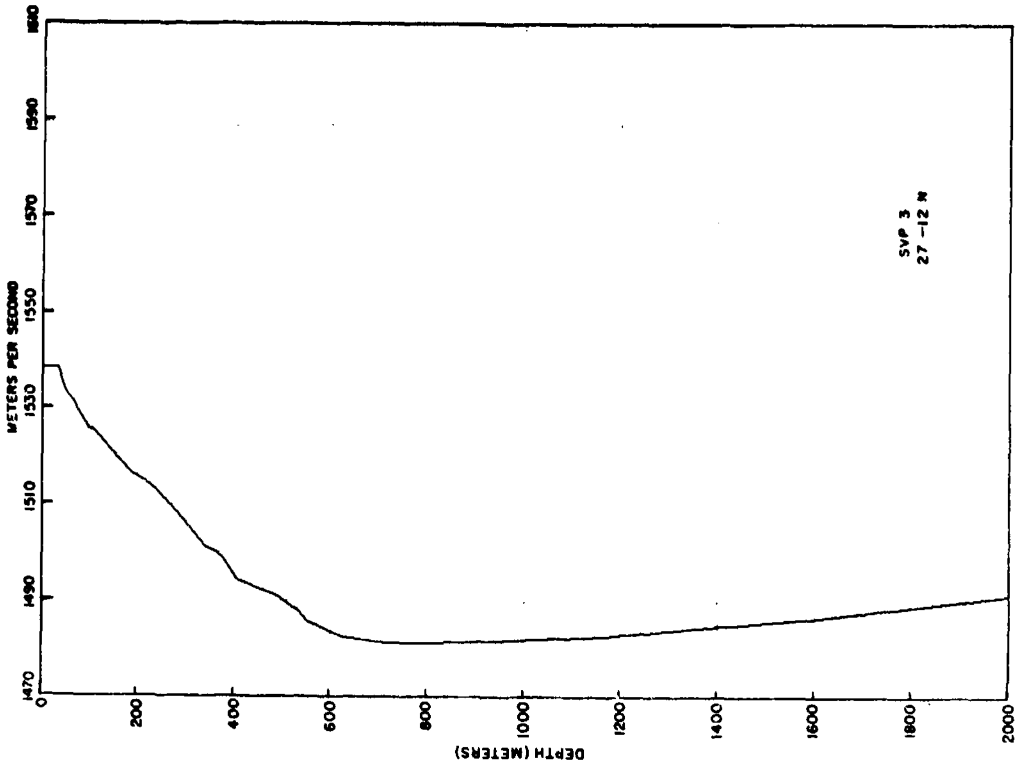

Fig. B-37 – Sound velocity profile 3 (U)

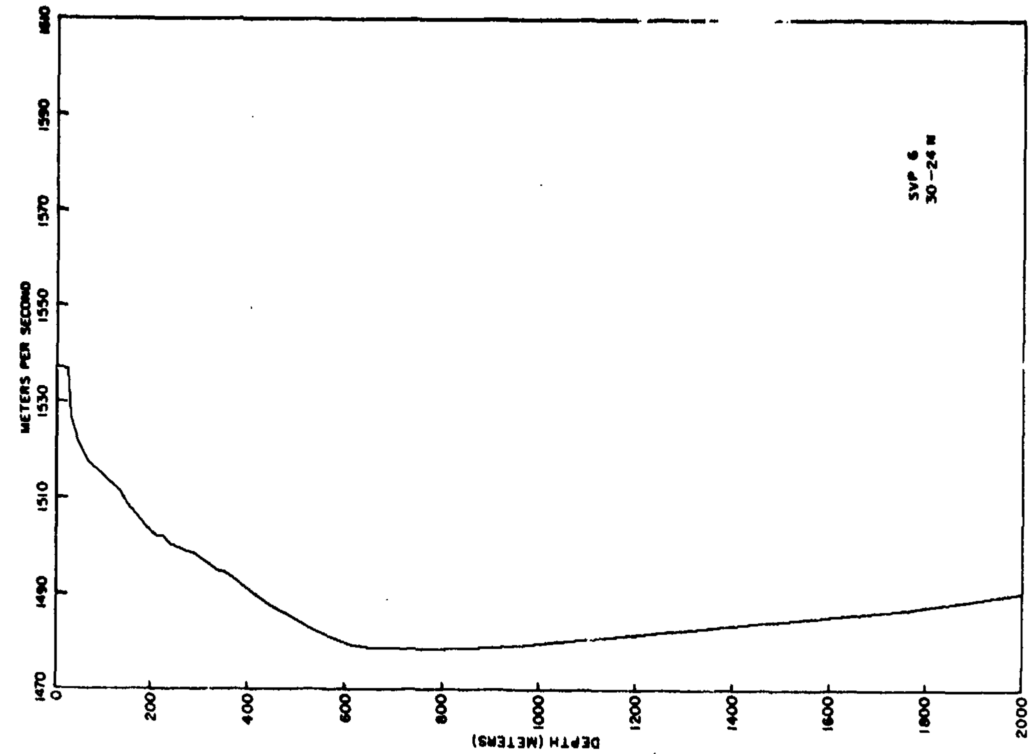

Fig. B-39 – Sound velocity profile 6 (U)

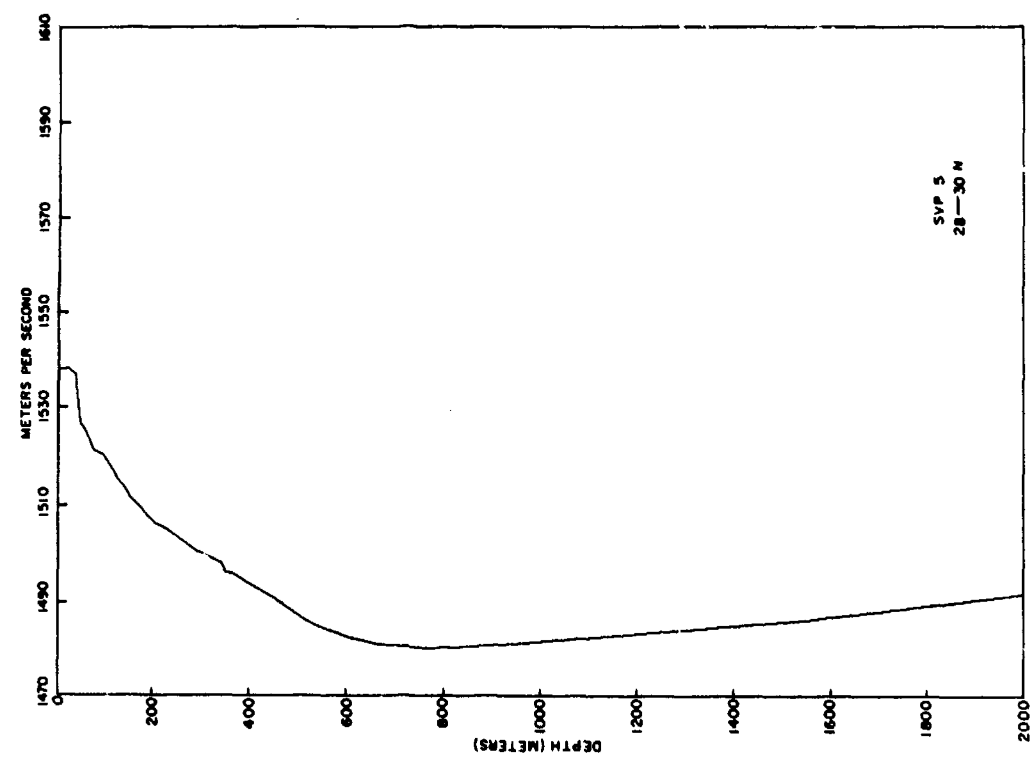

Fig. B-38 – Sound velocity profile 5 (U)

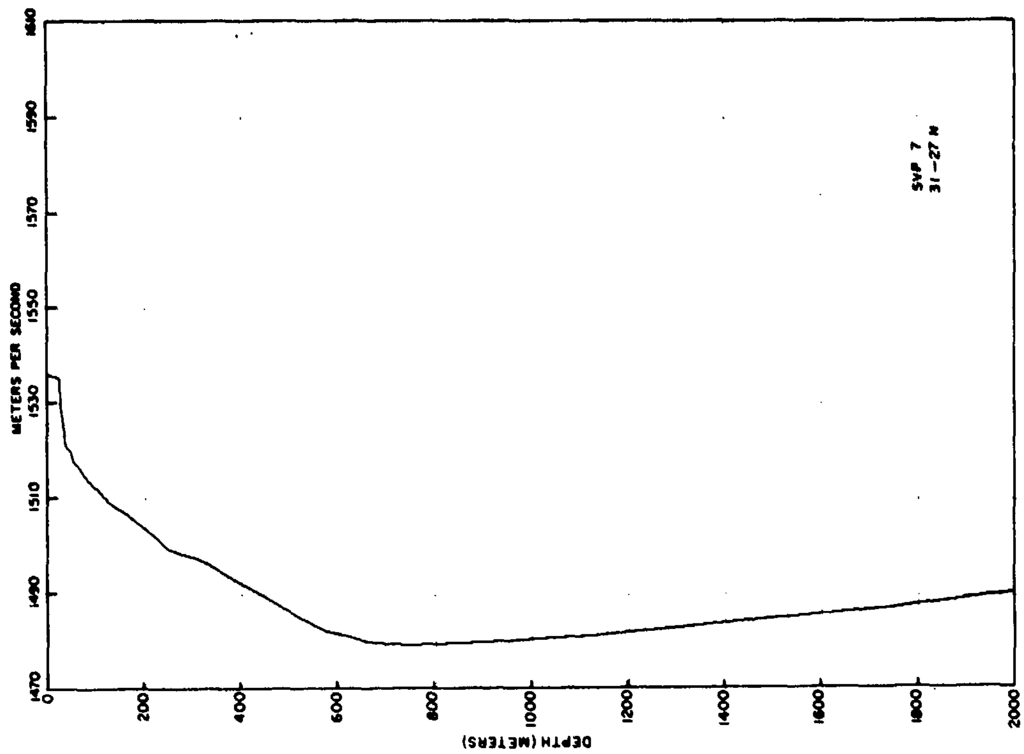

Fig. B-40 – Sound velocity profile 7 (U)

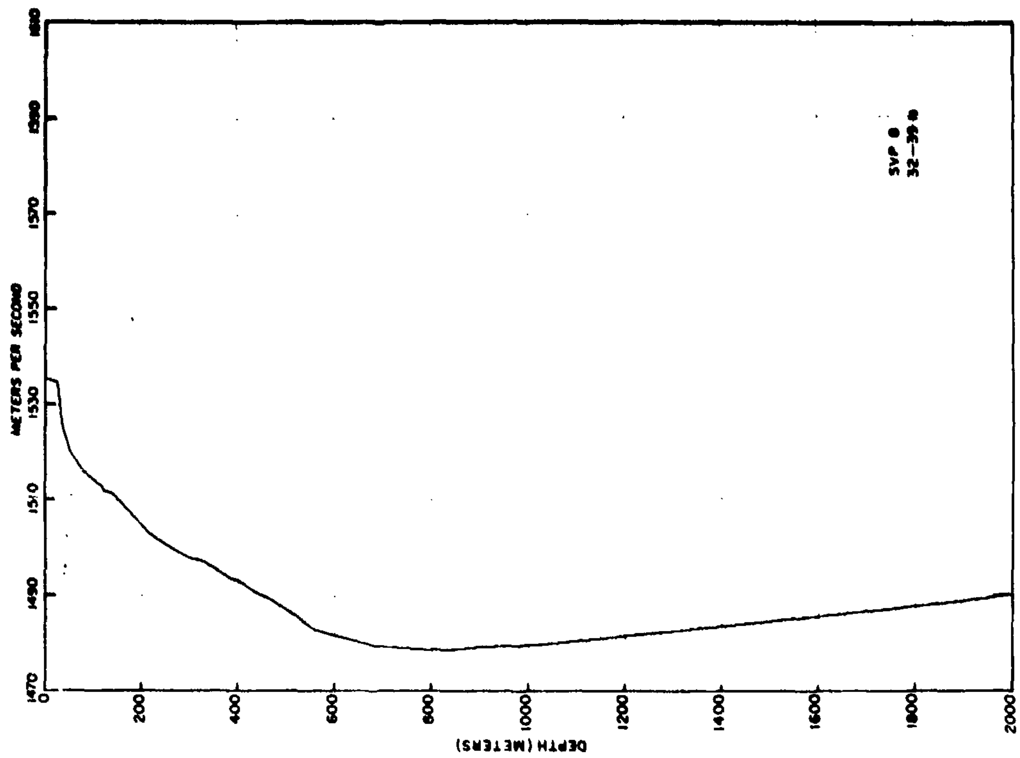

Fig. B-41 – Sound velocity profile 8 (U)

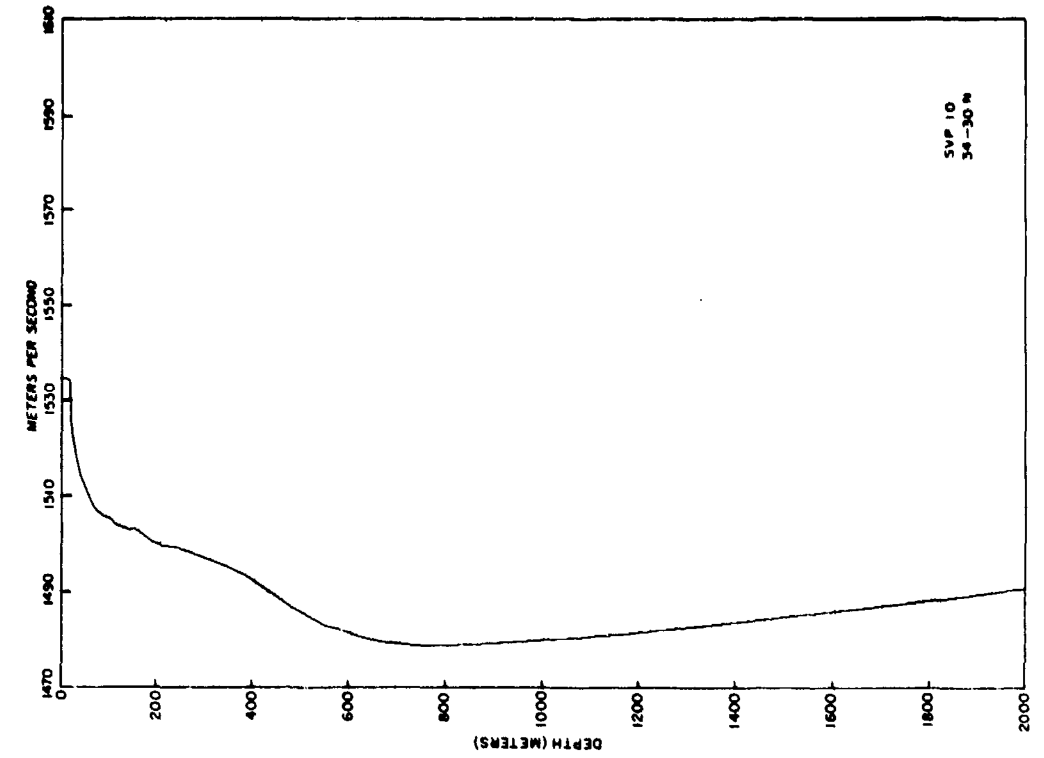

Fig. B-43 – Sound velocity profile 10 (U)

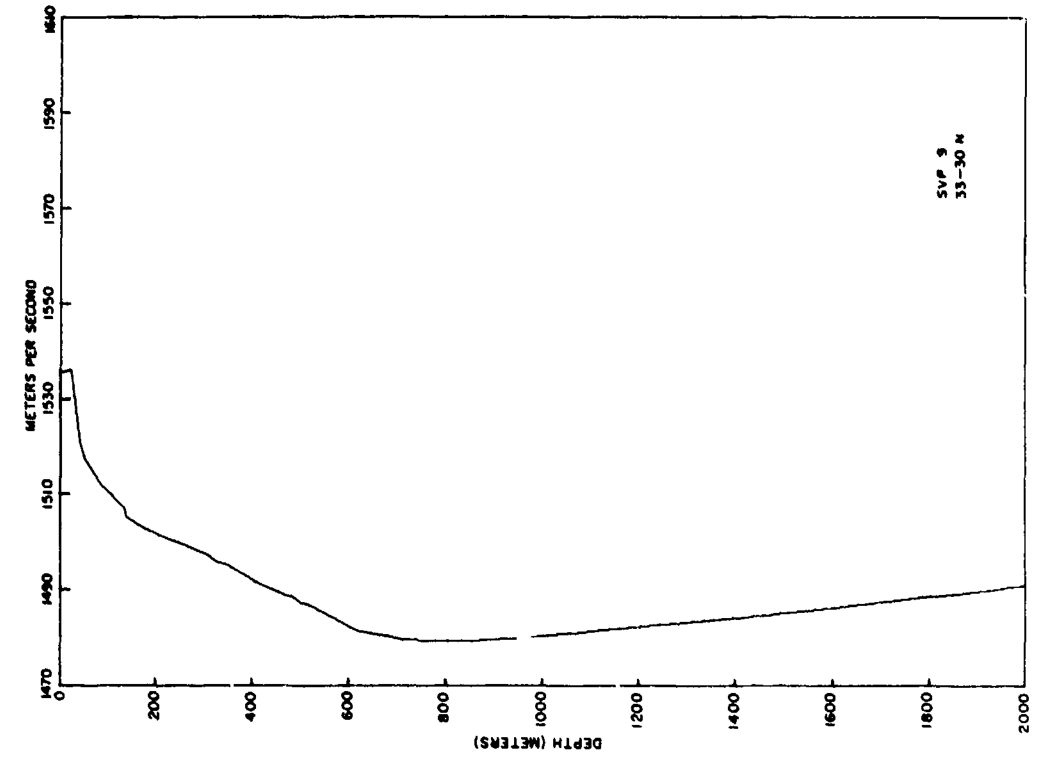

Fig. B-42 – Sound velocity profile 9 (U)

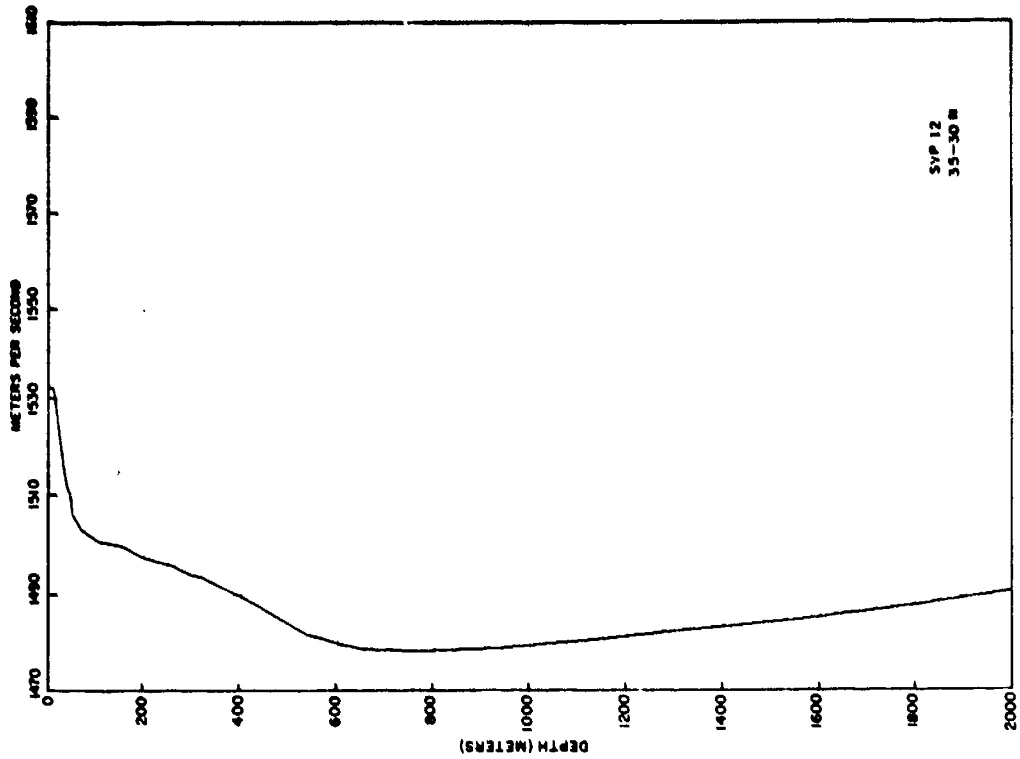

Fig. B-45 – Sound velocity profile 12 (U)

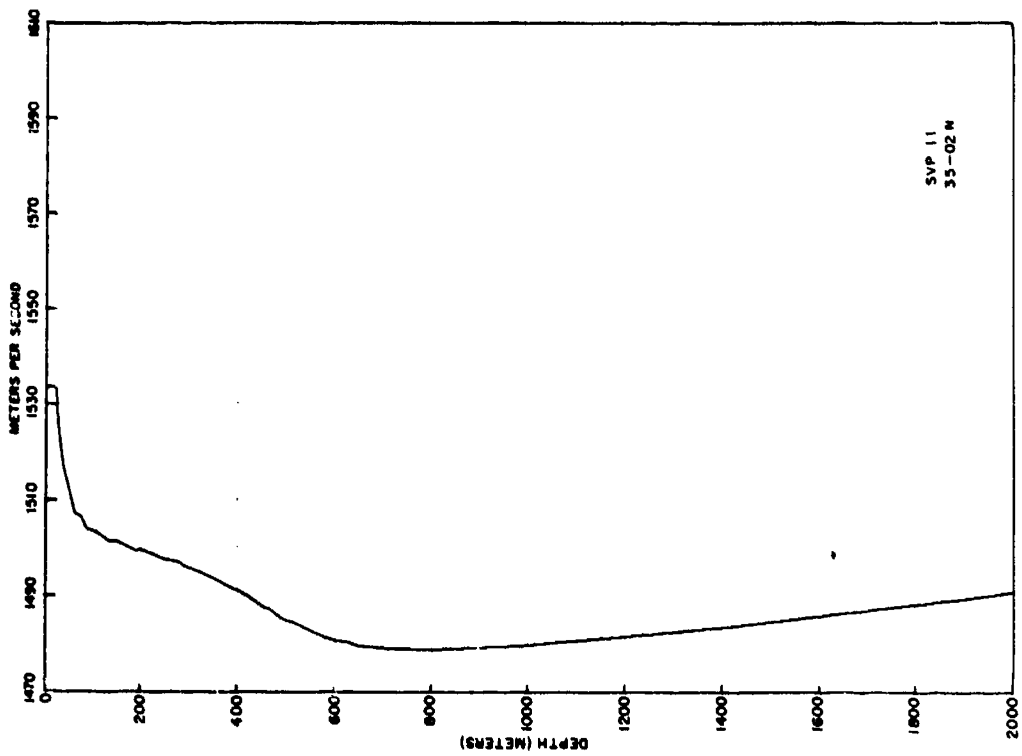

Fig. B-44 – Sound velocity profile 11 (U)

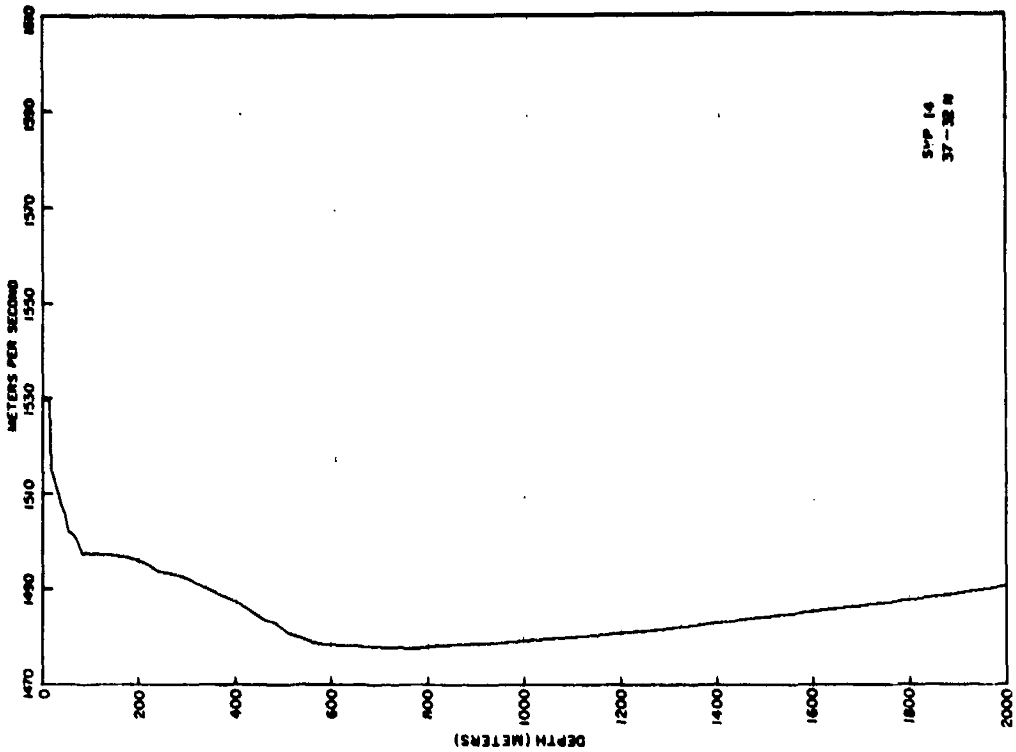

Fig. B-47 — Sound velocity profile 14 (U)

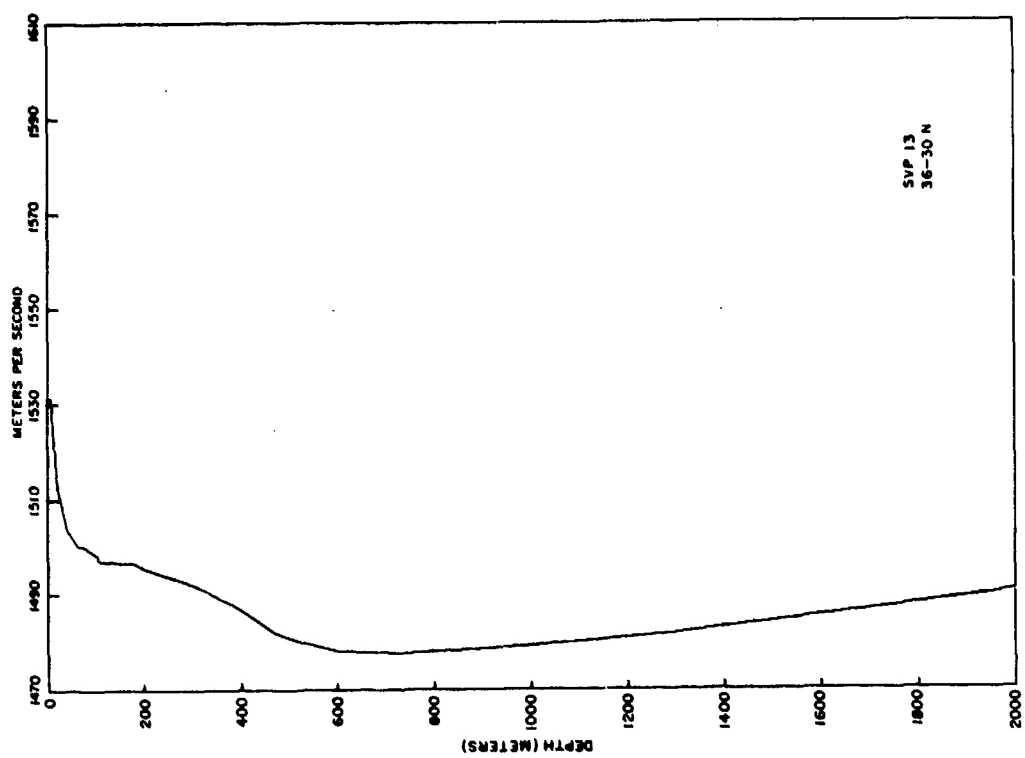

Fig. B-46 — Sound velocity profile 13 (U)

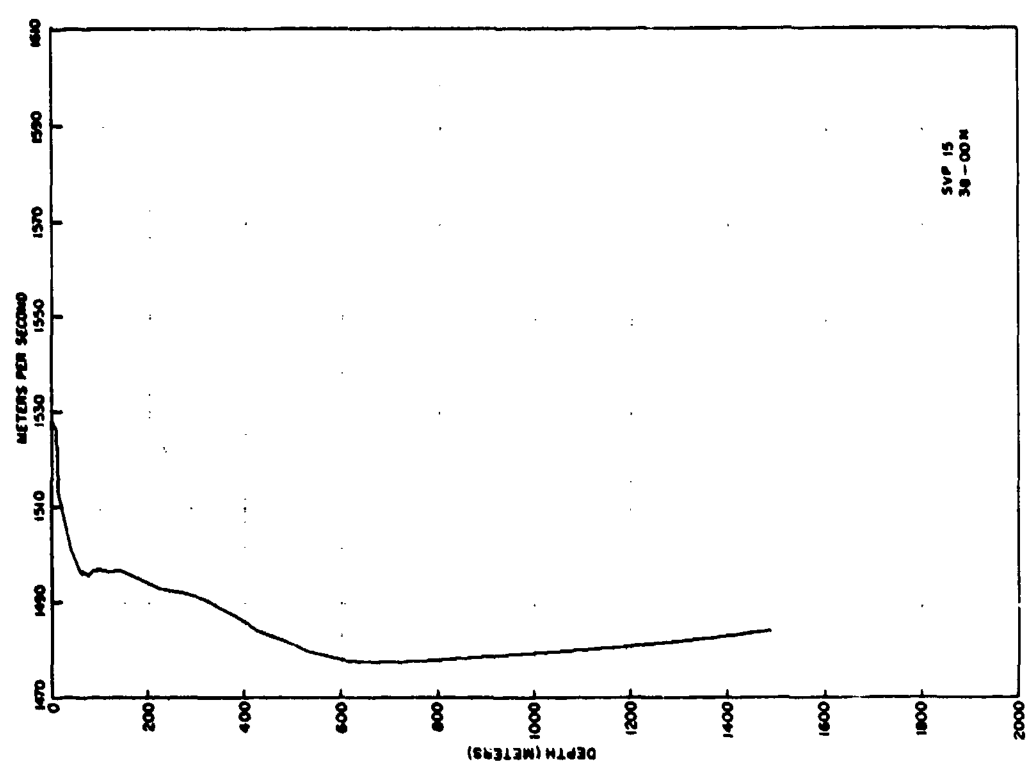

Fig. B-48 – Sound velocity profile 15 (U)

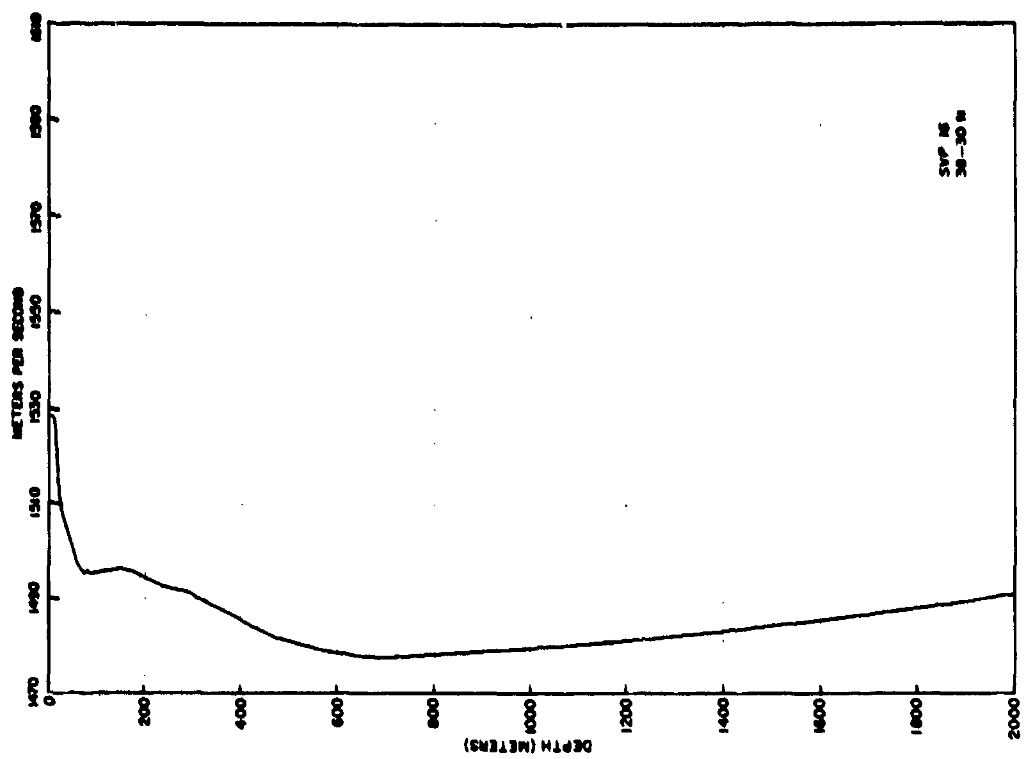

Fig. B-49 – Sound velocity profile 16 (U)

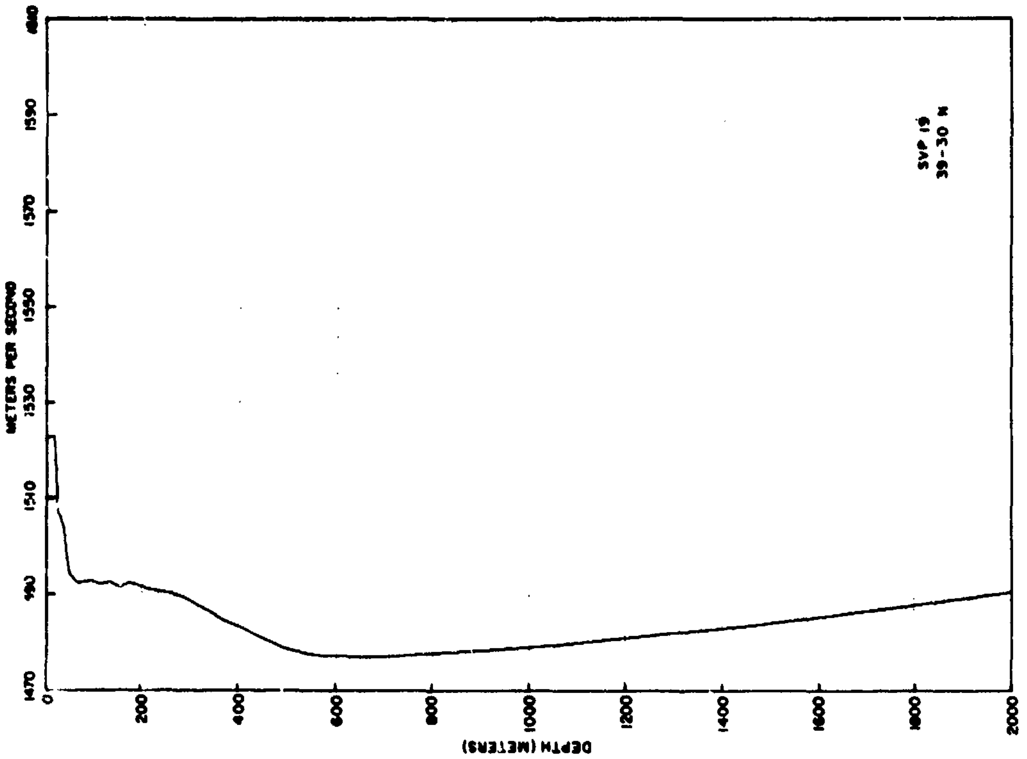

Fig. B-51 — Sound velocity profile 19 (U)

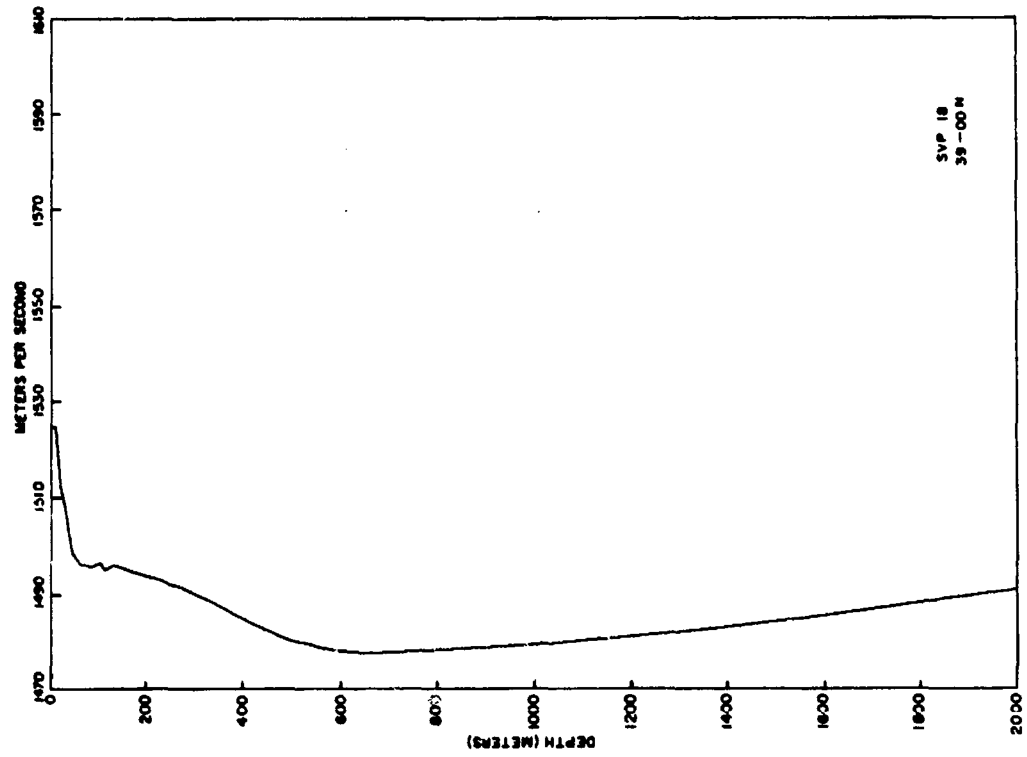

Fig. B-50 — Sound velocity profile 18 (U)

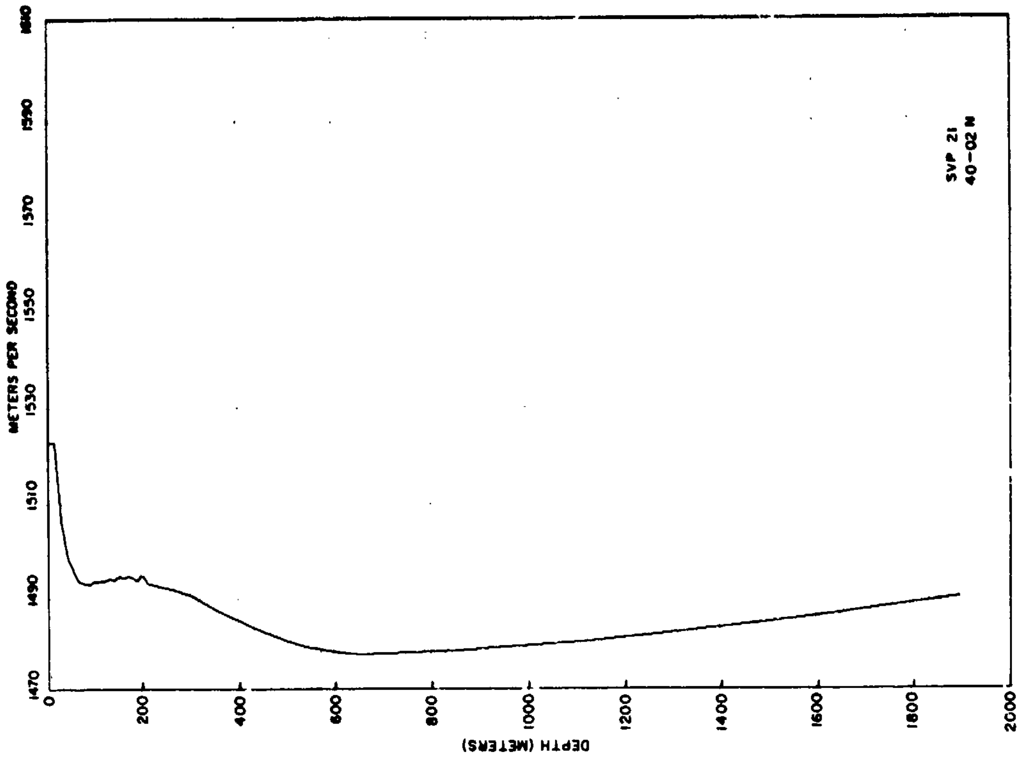

Fig. B-53 – Sound velocity profile 21 (U)

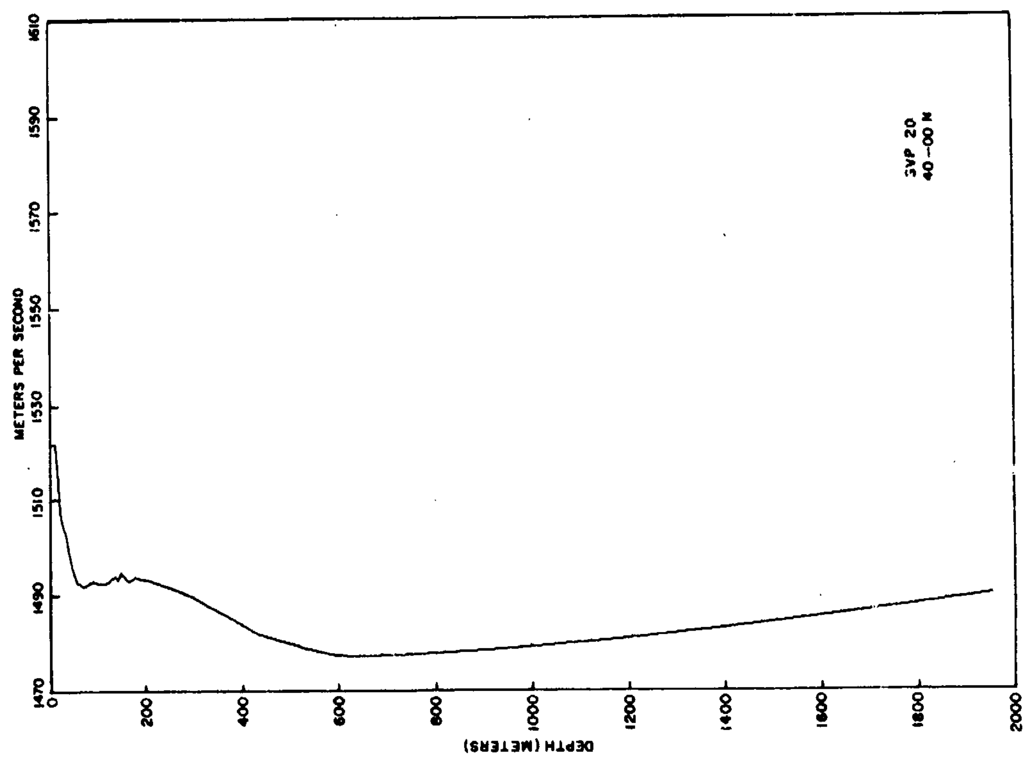

Fig. B-52 – Sound velocity profile 20 (U)

Tables B-V through B-XXV are listings of IES depths, and the corresponding measured sound velocity, temperature, and pressure depth. There are several schemes for converting pressure sensor data to depth data but probably the most commonly used method is the one used here, i.e., a constant density throughout the water column from the surface to 6100 meters is assumed and the output frequency of the sensor is converted to depth through a linear relationship to depth. Only IES depth and measured sound velocity data were transmitted to FWC Pearl during PARKA I. During Phase 2 of PARKA I two velocimeters were carried aboard MARYSVILLE. The first of these suffered an excessive amount of water leakage into the transducer housings after eight lowerings (a fairly common occurrence after continued use of these velocimeters) and it had to be replaced on the package by the second velocimeter. Nine lowerings were made with this velocimeter before the electronics were accidentally flooded. Parts from the two velocimeters were then put together to get an operational velocimeter and the final four lowerings were made with this hybrid instrument. Of course, no calibration data was available for this velocimeter and therefore the SVP data for lowerings 18 through 21 were not transmitted to FWC. This hybrid velocimeter was calibrated at WHOI after PARKA I and the data for these lowerings were worked up after that time.

g. **Temperature Data**

The temperature data listed in Tables B-V through B-XXV were collected with the Hytech model 4005 temperature sensor and are probably accurate to ±.03°C. It was recognized fairly early in the cruise that the XBT data frequently did not agree with data from this sensor. An analysis of these discrepancies is discussed in Section j. of this appendix.

h. **Pressure Depth versus IES Depth**

In an earlier part of this report it was mentioned that the pressure sensor output frequency was assumed to be linearly related to the depth of the sensor. With this sensor the zero gauge pressure output frequency is 9712.0 Hz. With 8900 pounds per square inch gauge applied to the sensor the output frequency should be 11,289.1 Hz. It was assumed (as is usually done with this model sensor) that a frequency of 11,288 Hz was equivalent to a depth of 6100 meters and that the depth for intermediate frequencies was related linearly to those intermediate frequencies. A set of tables for pressure sensor depth was computed based on the above ideal applied pressure-frequency relationship. The calibration of this particular pressure sensor with a deadweight tester at WHOI immediately prior to the air shipment of the equipment to Honolulu showed the actual measured values to be such that the greatest error at any of the points tested would represent an error of about 4 meters in depth. This is well within the manufacturers stated tolerance of linearity for these sensors. The listed values of pressure sensor depth in Tables B-V through B-XXV were taken from this set of tables. The very first SVP lowering showed that the initial calibration of this sensor was no longer valid. Subsequent lowerings also confirmed this calibration shift. When the sensor was recalibrated after the cruise it was found that the pressure sensor tables constructed on the basis of the initial calibration were indeed not valid. A comparison of the pressure depth and the IES depth throughout the lowering indicates that corrections to the pressure depths based upon the post cruise calibration are not

warranted, since there are indications in the data that there were numerous discrete changes in the calibration of this sensor. To complicate the situation further it was also noticed during the cruise (and has been on numerous other occasions not only with this particular sensor but others of the same model as well) that the zero gauge pressure frequency output will often shift in value. It is not clear from the data whether or not all values of depth for a particular lowering should be corrected by that amount which would equate the zero gauge pressure to zero meters of depth. It should be mentioned that prior to the cruise the sensor output frequency at room temperature and atmospheric pressure was compared to the zero degree C, atmospheric pressure output frequency. The frequency change was 0.3 Hz which corresponds roughly to one meter of depth. This is not a significant change in relation to other changes which occurred.

i. **Notes on Operations**

The winch on board MARYSVILLE presented a number of problems. Its slow speed was a handicap, but in addition, breaks developed in the welded joints between the drum and flanges. This caused a partial collapse of the drum in places and thus the cable could not be laid evenly and tightly over the entire length of the drum. Eventually these poor lays caused the loss of a considerable portion of the cable and operations were then limited to a maximum depth of about 2000 meters with the package. This was the major operational problem.

Another problem which became evident after the cruise was that the data received at FNWC in Monterey were frequently in error. By frequently it is meant that errors occurred often enough to be troublesome. Of 17 SVP's transmitted from MARYSVILLE each had at least one, and usually more than one, error in the data as received by FNWC. Often the error was easily recognized as an error, but the correct value to be used would sometimes be difficult to guess. The method of depth determination used aboard MARYSVILLE required a number of hand computations and there were some errors made in the listing of several of these SVP's. These errors were, however, usually rather small and for most purposes insignificant. The vast majority of significantly erroneous data received at FNWC from MARYSVILLE were almost certainly due to radio transmission errors. The fact that the data was transmitted from MARYSVILLE via CW is probably significant.

It is unclear at this time whether the pressure sensor on the package was operating normally. This is probably the first time that such a wealth of data was collected where the operation of a "typical" pressure sensor could be compared with what should be the standard of comparison for depth determination: the IES-velocimeter system. The change in zero pressure output frequency of this sensor was not unexpected based on previous experience with this sensor and others of the same model, but the change in maximum applied pressure output frequency as determined by the deadweight tester definitely confused the analysis of the data. Only further tests will confirm whether this sensor was operating normally or not. This does point up one serious drawback of a pressure sensor, however, and that is that in at least some cases the calibration of the instrument can change. This presents a serious problem at sea where a deadweight tester cannot be used.

Table B-V
MARYSVILLE Sound Velocimeter Data (U)
SVP #1 27 August 1968 24 – 59.2N
157 – 52.0W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1538.6	26.76	2
23	1539.0	26.73	32
35	1539.1	26.64	43
40	1537.9	26.02	48
46	1535.2	24.28	54
49	1533.1	23.88	57
52	1531.7	23.68	60
64	1528.9	22.15	71
73	1527.3	21.57	78
84	1525.8	20.91	87
116	1520.5	18.91	114
139	1518.3	18.00	139
194	1512.1	17.98	197
252	1503.6	12.94	252
305	1496.6	10.69	306
360	1493.6	9.61	359
386	1491.7	9.02	386
414	1490.2	8.51	412
463	1486.6	7.37	465
488	1486.2	7.10	488
514	1485.2	6.73	515
564	1481.8	5.68	566
592	1480.4	5.22	595
703	1479.8	4.60	701
808	1479.9	4.19	810
996	1481.1	3.63	998
1244	1482.8	3.08	1249
1465	1484.5	2.64	1468
1729	1487.4	2.25	1741
2003	1490.8	1.95	2017
2384	1496.2	1.71	2402
2616	1499.8	1.63	2638
2992	1505.8	1.53	3021
3297	1511.1	1.48	3328
3580	1515.9	1.46	3608
3836	1520.4	1.45	3870
4205	1527.0	1.46	4246
4497	1531.8	1.50	4545

Table B-VI
MARYSVILLE Sound Velocimeter Data (U)
SVP #2 27 August 1968 25 – 34N
157 – 53W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1538.6	26.7	
15	1538.6	26.61	19
23	1538.7	26.56	28
38	1538.5	26.35	43
43	1537.1	25.72	49
46	1535.2	24.85	52
50	1534.0	24.34	56
53	1532.6	23.79	59
69	1530.5	22.64	73
85	1528.0	21.71	89
102	1527.2	21.41	106
110	1525.7	20.69	112
121	1524.9	20.33	120
130	1522.7	19.47	135
146	1520.2	18.57	149
181	1517.0	17.29	180
210	1513.8	16.11	210
224	1510.7	15.06	224
255	1507.0	13.87	253
283	1503.5	12.72	281
298	1501.2	12.02	295
371	1494.5	9.81	367
425	1490.6	8.54	422
475	1487.5	7.47	474
526	1484.4	6.50	524
631	1481.0	5.18	629
779	1480.2	4.35	778
824	1480.6	4.26	822
914	1480.9	3.95	909
1001	1480.8	3.58	1000
1167	1482.3	3.24	1175
1443	1484.6	2.70	1448
1731	1487.4	2.27	1738
2028	1491.2	1.95	2039
2392	1496.2	1.68	2410
2699	1500.9	1.58	2720
3158	1508.6	1.47	3183

Table B-VII
MARYSVILLE Sound Velocimeter Data (U)
SVP #3 28 August 1968 26 – 30N
157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1538.0	26.44	1
23	1538.3	26.44	24
35	1538.4	26.24	35
38	1536.1	24.99	40
47	1532.4	23.65	47
55	1530.6	22.85	53
67	1527.1	21.27	69
83	1524.6	20.47	83
99	1523.9	19.97	98
111	1521.3	19.15	111
126	1519.8	18.52	126
139	1516.9	17.52	142
152	1515.2	16.88	156
167	1514.5	16.53	171
196	1512.0	15.67	201
228	1509.8	14.86	232
275	1502.7	12.51	275
291	1500.8	11.92	291
335	1497.2	10.71	335
348	1497.0	10.59	348
364	1496.4	10.31	364
379	1495.3	9.97	378
393	1493.8	9.55	393
420	1492.8	9.12	421
478	1487.6	7.52	478
536	1484.7	6.51	536
681	1480.8	4.93	683
795	1480.0	4.24	796
823	1480.1	4.13	824
1162	1482.7	3.39	1163
1431	1484.9	2.85	1438
1574	1486.3	2.61	1579
1998	1491.1	2.04	2010
2544	1498.8	1.68	2561
3217	1509.8	1.50	3244
3825	1520.2	1.46	3859
4388	1530.4	1.47	4433
4948	1540.4	1.51	5000

Table B-VIII
MARYSVILLE Sound Velocimeter Data (U)
SVP #4 28 August 1968 27 – 12N
157 – 58W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1538.3	26.66	2
35	1538.3	26.47	37
51	1533.5	24.27	53
69	1531.1	23.00	68
84	1528.5	21.87	84
100	1525.9	20.89	97
107	1525.5	20.61	104
144	1521.3	18.94	141
189	1516.4	17.11	187
218	1514.8	16.45	215
245	1512.7	15.63	242
342	1501.2	11.80	338
367	1499.9	11.32	364
379	1498.7	10.91	376
405	1494.4	9.61	402
490	1491.0	8.26	489
525	1488.3	7.53	521
532	1488.1	7.42	528
554	1485.5	6.66	552
627	1482.4	5.60	625
717	1481.2	4.92	715
803	1481.1	4.51	798
936	1481.5	4.06	934
1167	1482.7	3.40	1165
1384	1484.7	2.98	1387
1576	1486.2	2.60	1581
1905	1490.0	2.19	1913
2302	1495.2	1.82	2314
2987	1505.8	1.57	3000

Table B-IX
MARYSVILLE Sound Velocimeter Data (U)
SVP #5 29 August 1968 28 – 30N 157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temper-ature (degrees Celsius)	Pressure Depth (meters)
0	1538.0	26.60	–1
23	1538.4	26.29	25
40	1537.0	25.26	42
50	1526.9	21.40	51
60	1525.6	20.85	57
77	1521.1	19.24	74
98	1520.1	18.71	89
128	1515.1	17.00	122
144	1513.2	16.29	137
151	1511.6	15.80	145
208	1505.8	13.75	203
223	1505.2	13.53	219
289	1500.1	11.72	282
323	1498.7	11.16	315
344	1497.5	10.70	336
352	1495.6	10.20	345
368	1495.3	10.03	361
449	1490.4	8.38	441
513	1485.8	6.94	503
542	1484.4	6.46	536
603	1482.1	5.59	598
668	1480.5	4.94	664
766	1479.9	4.39	759
856	1480.1	4.05	853
917	1480.5	3.89	914
1550	1485.8	2.60	1554
1999	1491.1	2.04	2008
2840	1503.5	1.62	2857

Table B-X
MARYSVILLE Sound Velocimeter Data (U)
SVP #6 30 August 1968 30 – 24N 157 – 51W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temper-ature (degrees Celsius)	Pressure Depth (meters)
0	1537.1	26.0	–2
26	1536.8	25.45	23
31	1526.9	21.73	28
48	1521.5	19.80	45
70	1517.3	18.09	65
136	1511.2	15.81	130
148	1508.9	15.01	143
188	1504.0	13.38	181
213	1501.8	12.64	206
227	1501.8	12.56	218
239	1500.2	12.02	232
276	1498.6	11.38	269
288	1498.3	11.25	282
339	1494.7	10.15	332
354	1494.3	9.88	344
388	1491.8	9.05	380
419	1489.5	8.48	409
445	1487.5	7.77	438
462	1486.5	7.48	454
474	1486.0	7.31	466
533	1482.4	6.11	526
605	1479.3	5.09	597
653	1478.6	4.71	646
774	1478.4	4.08	767
912	1478.9	3.67	904
960	1479.2	3.52	952
1275	1482.1	2.94	1271
1424	1483.5	2.70	1420
1762	1486.9	2.19	1761
2015	1490.3	1.96	2016
2209	1493.1	1.83	2211

Table B-XI
MARYSVILLE Sound Velocimeter Data (U)
SVP #7 30 August 1968 31 – 27N
157 – 49W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1536.0	25.7	-8
27	1535.0	25.26	14
29	1529.2	23.51	16
41	1520.5	19.57	32
51	1519.6	19.19	43
58	1517.4	18.43	50
72	1516.0	17.78	62
79	1514.5	17.35	69
99	1512.1	16.46	89
107	1511.8	16.23	95
110	1511.3	16.12	98
132	1508.8	15.25	121
171	1506.2	14.25	162
211	1502.8	13.07	201
223	1502.0	12.82	214
251	1499.2	11.85	241
278	1498.1	11.44	266
290	1497.8	11.31	278
315	1497.0	10.91	305
342	1495.7	10.44	331
395	1492.4	9.34	385
523	1484.9	6.84	515
575	1482.0	5.91	565
677	1479.4	4.83	667
752	1479.0	4.39	742
903	1479.5	3.85	898
1125	1480.9	3.30	1122
1410	1483.5	2.79	1413
1751	1486.5	2.24	1756
1983	1489.5	1.98	1992
2079	1491.1	1.91	2087
2195	1492.7	1.85	2206

Table B-XII
MARYSVILLE Sound Velocimeter Data (U)
SVP #8 31 August 1968 32 – 39N
157 – 55W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1535.2	25.4	-15
11	1535.2	25.40	-4
20	1534.8	25.18	+6
27	1534.5	24.94	13
36	1526.0	21.66	23
53	1520.0	19.29	41
79	1516.0	17.83	65
119	1512.8	16.53	106
126	1511.8	16.23	114
144	1511.2	15.91	131
218	1502.8	13.10	201
232	1501.9	12.78	213
268	1499.5	11.88	250
304	1497.8	11.23	284
328	1497.1	10.88	308
384	1493.5	9.66	368
407	1492.8	9.36	392
434	1490.9	8.76	417
453	1489.8	8.39	441
471	1488.8	8.06	458
533	1484.9	6.77	521
560	1482.9	6.25	549
644	1480.3	5.19	632
689	1479.4	4.74	677
798	1478.7	4.14	787
840	1478.7	3.99	829
903	1479.2	3.83	891
1011	1479.7	3.50	1002
1118	1480.5	3.25	1107
1422	1483.8	2.78	1412
1839	1488.1	2.18	1840
1926	1489.1	2.08	1928
2021	1490.4	1.99	2026
2043	1490.7	1.99	2043

Table B-XIII
MARYSVILLE Sound Velocimeter Data (U)
SVP #9 31 August 1968 33 – 30N 157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1536.2	25.75	-10
2	1536.0	25.61	-7
9	1535.6	25.33	+2
16	1535.9	25.37	10
26	1536.0	25.37	18
44	1520.8	19.24	37
53	1517.4	18.25	45
88	1512.0	16.18	80
135	1507.0	14.25	120
139	1505.2	13.96	125
177	1502.8	13.05	165
229	1500.5	12.10	217
255	1499.7	11.76	241
306	1497.5	10.91	292
331	1495.9	10.36	319
345	1495.5	10.18	332
395	1492.7	9.19	382
406	1491.9	8.93	395
470	1488.9	7.92	459
486	1488.6	7.73	474
504	1487.2	7.32	494
518	1487.0	7.21	506
616	1481.7	5.47	606
656	1480.8	5.08	645
690	1480.2	4.76	680
713	1479.6	5.55	705
777	1479.4	4.23	768
851	1479.4	3.91	842
889	1479.6	3.78	878
935	1479.8	3.62	928
1448	1484.7	2.74	1444
1680	1487.1	2.35	1682
1915	1489.8	2.07	1918
2025	1491.4	1.98	2031
2242	1494.4	1.82	2251

Table B-XIV
MARYSVILLE Sound Velocimeter Data (U)
SVP #10 31 August 1968 34 – 30N 157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1534.8	25.25	-5
13	1534.6	25.01	+8
19	1534.2	24.82	14
22	1525.3	21.07	17
31	1519.3	19.10	27
41	1514.7	17.44	37
67	1508.2	15.19	58
77	1506.8	14.71	69
95	1505.5	14.24	87
103	1505.4	14.18	93
115	1504.0	13.70	106
143	1503.0	13.27	132
155	1503.2	13.24	144
190	1500.6	12.35	179
215	1499.6	11.94	203
240	1499.4	11.75	227
290	1497.6	11.03	277
340	1495.5	10.22	327
352	1495.2	10.09	337
389	1493.2	9.36	378
456	1488.8	7.92	445
480	1487.0	7.34	470
504	1485.8	6.97	491
553	1482.9	6.05	542
580	1482.2	5.77	566
623	1480.7	5.20	609
667	1479.6	4.72	656
738	1478.9	4.27	726
803	1478.8	3.96	794
898	1479.2	3.65	880
1153	1481.0	3.06	1142
1382	1483.3	2.62	1374
1835	1488.5	2.12	1832
1923	1489.8	2.03	1923
2037	1491.4	1.95	2043
2082	1492.0	1.93	2085

Table B-XV
MARYSVILLE Sound Velocimeter Data (U)
SVP #11 1 September 1968 35 – 02N 157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1533.4	24.8	-11
18	1533.6	24.76	+5
23	1533.2	24.38	10
28	1525.8	21.43	16
37	1517.9	18.62	25
64	1507.2	14.94	56
77	1506.3	14.60	65
88	1504.0	13.87	76
112	1503.1	13.47	98
135	1501.4	12.82	126
151	1501.4	12.75	140
192	1499.3	11.99	179
204	1499.7	12.00	193
231	1498.6	11.59	219
246	1497.9	11.31	235
283	1497.0	10.93	258
289	1496.3	10.62	276
355	1493.7	9.67	338
392	1491.7	8.94	–
404	1491.7	8.75	–
440	1488.9	8.05	429
455	1487.6	7.61	452
468	1487.3	7.45	461
480	1486.4	7.22	470
490	1485.5	6.95	482
505	1484.9	6.71	495
517	1484.6	6.68	510
579	1481.4	5.54	571
605	1480.7	5.25	597
627	1480.3	5.05	622
652	1479.6	4.81	646
716	1479.0	4.39	710
801	1478.8	3.99	793
982	1479.7	3.41	976
1269	1482.2	2.88	1264
1432	1483.9	2.63	1430
1929	1489.8	2.01	1933
2024	1491.1	1.94	2030
2232	1493.9	1.80	2239

Table B-XVI
MARYSVILLE Sound Velocimeter Data (U)
SVP #12 1 September 1968 35 – 30N 157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1533.4	24.8	-7
14	1533.2	24.60	+14
35	1516.4	18.19	30
43	1512.1	16.70	38
49	1511.2	16.26	43
55	1507.0	14.97	50
62	1505.7	14.53	56
68	1504.6	14.15	63
74	1503.7	13.84	68
109	1501.2	12.92	101
130	1500.8	12.72	120
158	1500.1	12.39	146
194	1498.1	11.61	187
206	1497.8	11.47	197
259	1496.1	10.77	249
308	1494.0	9.97	299
323	1493.9	9.88	312
396	1490.2	8.59	386
471	1485.9	7.16	461
541	1481.9	5.88	530
611	1479.6	4.99	601
660	1478.7	4.59	648
704	1478.3	4.31	691
775	1478.2	3.98	764
935	1478.9	3.49	924
1158	1480.8	3.00	1152
1303	1482.3	2.77	1297
1560	1484.9	2.40	1555
1790	1487.7	2.12	1789
1984	1490.3	1.94	1989

Table B-XVII
MARYSVILLE Sound Velocimeter Data (U)
SVP #13 1 September 1968 36 – 30N
157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temper- ature (degrees Celsius)	Pressure Depth (meters)
0	1531.1	24.1	-5
9	1531.2	24.03	+1
21	1512.4	16.98	17
32	1508.4	15.57	28
41	1503.8	14.12	39
65	1500.1	12.84	62
78	1500.2	12.78	76
107	1498.2	12.05	100
117	1497.1	11.68	112
125	1496.8	11.53	122
135	1497.0	11.67	133
150	1496.5	11.35	145
179	1496.6	11.22	176
204	1495.4	10.81	199
270	1493.1	9.89	261
312	1491.6	9.32	296
354	1489.2	8.48	341
377	1488.2	8.11	364
469	1482.2	6.20	460
523	1480.0	5.48	509
545	1479.3	5.17	535
606	1478.0	4.65	592
740	1477.7	3.99	729
980	1479.0	3.29	968
1151	1480.4	2.93	1138
1289	1481.7	2.68	1283
1470	1483.8	2.45	1460
1749	1487.1	2.11	1743
1949	1489.8	1.95	1950
2013	1490.7	1.90	2011

Table B-XVIII
MARYSVILLE Sound Velocimeter Data (U)
SVP #14 2 September 1968 37 – 32N
157 – 52W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temper- ature (degrees Celsius)	Pressure Depth (meters)
0	1529.7	23.5	
15	1529.7	23.41	14
19	1514.8	17.84	19
40	1507.7	15.31	35
48	1505.6	14.60	41
56	1502.0	13.43	48
65	1501.3	13.14	50
71	1500.5	12.91	57
78	1499.3	12.55	64
86	1497.2	11.91	71
92	1497.7	12.03	77
101	1497.3	11.75	84
137	1497.2	11.67	117
180	1496.5	11.22	161
215	1495.3	10.75	195
239	1493.9	10.24	222
268	1493.2	9.94	249
294	1492.3	9.57	276
374	1488.5	8.21	358
403	1487.1	7.72	387
459	1483.7	6.65	441
487	1482.8	6.31	468
511	1480.9	[illegible].74	494
561	1478.9	4.92	549
588	1478.4	4.77	575
773	1477.7	3.94	762
826	1478.2	3.78	815
952	1478.8	3.34	943
1265	1481.3	2.70	1258
1419	1483.1	2.48	1418
1689	1486.4	2.18	1689
1808	1487.9	2.06	1809
1933	1489.7	1.97	1937
2119	1492.1	1.85	2119
2221	1493.7	1.78	2226

Table B-XVIX
MARYSVILLE Sound Velocimeter Data (U)
SVP #15 3 September 1968 38 – 00N
157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temper-ature (degrees Celsius)	Pressure Depth (meters)
0	1528.2	22.8	
12	1526.2	21.97	9
16	1513.2	17.30	16
42	1501.0	13.11	40
63	1495.8	11.69	57
66	1496.6	11.85	61
78	1495.7	11.53	72
87	1496.5	11.71	81
103	1496.8	11.71	95
118	1496.4	11.52	116
143	1496.5	11.41	137
198	1494.2	10.54	190
225	1492.8	10.03	215
258	1492.2	9.71	250
273	1492.0	9.60	264
321	1490.4	8.97	312
348	1488.8	8.41	341
372	1487.6	8.02	36
410	1485.3	7.26	400
426	1484.0	6.86	417
510	1480.8	5.70	502
531	1479.7	5.35	524
614	1477.7	4.51	608
652	1477.4	4.32	640
704	1477.4	4.08	697
766	1477.6	3.85	760
905	1478.5	3.50	897
1042	1479.5	3.16	1037
1179	1480.5	2.86	1175
1360	1482.3	2.58	1359
1488	1484.0	2.40	1483

Table B-XX
MARYSVILLE Sound Velocimeter Data (U)
SVP #16 3 September 1968 38 – 30N
157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/ second)	Temper-ature (degrees Celsius)	Pressure Depth (meters)
0	1527.9	22.8	-7
6	1528.0	22.71	+1
13	1527.9	22.64	8
15	1527.4	22.39	10
23	1511.8	16.81	19
30	1507.6	15.42	26
59	1497.2	11.99	53
75	1495.0	11.38	76
83	1495.5	11.45	81
89	1495.0	11.28	88
151	1496.0	11.20	144
181	1495.2	10.88	170
236	1492.4	9.86	224
276	1491.4	9.42	265
289	1491.2	9.29	278
315	1489.6	8.76	306
358	1487.6	8.07	346
395	1485.5	7.36	386
420	1484.2	6.92	411
471	1481.5	6.04	462
574	1478.8	4.92	569
653	1477.6	4.32	643
706	1477.4	4.08	698
888	1478.5	3.53	880
1163	1480.5	2.89	1158
1243	1481.3	2.76	1235
1388	1482.8	2.53	1385
1628	1485.6	2.25	1627
1878	1488.9	2.01	1883
1986	1490.5	1.95	1992
2124	1492.5	1.86	2132
2266	1494.5	1.79	2272

Table B-XXI
MARYSVILLE Sound Velocimeter Data (U)
SVP #17 3 September 1968 39 – 00N
157 - 49W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1524.9	21.7	-8
10	1525.1	21.70	+3
14	1521.2	20.09	7
18	1513.5	17.16	11
21	1509.2	15.97	16
38	1503.5	13.89	32
44	1500.0	12.90	40
54	1498.3	12.37	48
63	1497.0	11.97	57
128	1495.4	11.17	122
192	1493.7	10.43	180
274	1491.4	9.40	261
292	1490.8	9.16	281
308	1490.2	8.93	298
398	1485.3	7.30	485
472	1481.5	6.03	460
543	1479.2	5.20	533
630	1477.3	4.38	619
710	1477.3	4.08	697
763	1477.8	3.91	752
867	1478.4	3.62	855
988	1479.1	3.33	978

Table B-XXII
MARYSVILLE Sound Velocimeter Data (U)
SVP #18 4 September 1968 39 – 00N
157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1524.7	21.6	-5
14	1524.7	21.47	+8
24	1512.4	16.20	19
33	1507.8	15.38	27
39	1503.6	14.03	35
48	1498.3	12.44	44
66	1495.8	11.61	59
77	1495.9	11.62	68
84	1495.4	11.33	76
105	1496.1	11.51	95
114	1494.9	11.14	106
134	1495.8	11.26	126
199	1493.5	10.31	191
225	1492.8	10.01	216
249	1491.8	9.63	242
267	1491.3	9.40	258
314	1489.1	8.63	305
378	1485.8	7.50	370
441	1482.7	6.45	433
469	1481.2	5.96	461
498	1480.0	5.54	491
534	1479.3	5.21	527
555	1478.7	4.99	547
599	1477.8	4.59	591
651	1477.4	4.27	646
716	1477.5	4.01	709
810	1478.1	3.77	804
927	1478.8	3.46	920
1028	1479.4	3.18	1024
1164	1480.6	2.91	1166
1332	1482.2	2.64	1332
1548	1484.6	2.35	1549
1741	1487.1	2.14	1744
1914	1489.5	2.02	1920
2028	1491.1	1.92	2034
2089	1492.0	1.89	2096

Table B-XXIII
MARYSVILLE Sound Velocimeter Data (U)
SVP #19 4 September 1968 39 – 30N
157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)	I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1522.9	21.0	–3	370	1484.7	7.25	364
19	1523.0	20.9		397	1483.5	6.83	390
27	1507.0	15.38	23	496	1478.9	5.26	491
34	1506.2	14.98	27	521	1478.1	4.97	517
41	1503.8	13.87	35	547	1477.6	4.74	542
48	1497.5	12.03	43	575	1477.2	4.55	568
54	1494.2	11.30	49	677	1477.0	4.08	669
69	1492.3	10.69	64	727	1477.2	3.90	721
83	1492.6	10.70	77	802	1477.8	3.70	797
100	1492.9	10.70	93	903	1478.4	3.45	896
108	1492.3	10.49	101	966	1478.8	3.32	959
115	1492.2	10.42	109	1043	1479.4	3.15	1036
135	1492.5	10.45	126	1160	1480.5	2.91	1156
148	1491.8	10.15	142	1277	1481.6	2.70	1270
160	1491.7	10.06	155	1387	1482.8	2.54	1383
174	1492.3	10.11	167	1477	1483.8	2.42	1479
187	1492.2	10.03	181	1669	1486.2	2.22	1667
214	1491.2	9.64	207	1780	1487.6	2.11	1784
254	1490.4	9.24	246	1892	1489.1	2.03	1895
266	1490.2	9.12	259	2019	1491.0	1.94	2026
292	1489.3	8.76	286	2205	1493.8	1.85	2215
344	1486.3	7.74	338	2272	1494.6	1.80	2274

Table B-XXIV
MARYSVILLE Sound Velocimeter Data (U)
SVP #20 4 September 1968 40 – 00N
157 – 50W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1521.4	20.6	-9
14	1521.6	20.50	+4
17	1516.3	18.35	8
23	1507.3	15.40	14
29	1504.3	14.51	21
35	1502.8	14.00	27
41	1499.5	12.94	35
48	1496.5	12.93	41
60	1492.8	10.92	54
74	1491.9	10.59	67
93	1493.0	10.78	85
99	1492.5	10.59	92
118	1492.3	10.47	110
138	1494.0	10.79	128
144	1493.1	10.57	134
150	1494.9	10.96	142
168	1492.9	10.34	159
180	1493.9	10.51	173
199	1493.1	10.22	190
205	1493.1	10.17	197
281	1490.3	9.09	271
294	1489.8	8.92	283
305	1489.2	8.70	295
327	1487.8	8.24	318
372	1485.4	7.43	364
433	1481.8	6.25	431
507	1479.6	5.42	497
529	1478.9	5.14	520
595	1477.4	4.52	587
637	1477.1	4.26	628
657	1477.1	4.16	650
765	1477.5	3.83	758
938	1478.7	3.50	933
1178	1480.6	2.87	1175
1400	1483.0	2.56	1398
1616	1485.6	2.28	1618
1806	1488.0	2.10	1809
1953	1490.0	1.98	1957

Table B-XXV
MARYSVILLE Sound Velocimeter Data (U)
SVP #21 5 September 1968 40 – 02N
157 – 42W

I.E.S. Depth (meters)	Measured Sound Velocity (meters/second)	Temperature (degrees Celsius)	Pressure Depth (meters)
0	1521.5	20.6	–5
15	1521.6	20.47	+11
16	1521.1	20.08	12
17	1519.4	19.18	13
24	1512.3	17.10	19
30	1505.1	14.74	26
37	1500.8	13.37	32
44	1497.6	12.40	38
66	1492.8	10.94	58
74	1492.1	10.71	65
92	1491.9	10.53	83
98	1492.3	10.62	88
115	1492.6	10.59	106
122	1492.6	10.64	113
130	1493.0	10.61	118
142	1492.9	10.54	131
152	1493.6	10.65	142
159	1493.1	10.48	149
169	1493.6	10.54	161
181	1493.2	10.34	173
189	1492.5	10.16	178
195	1493.6	10.41	185
201	1493.5	10.36	190
212	1492.0	9.90	202
266	1490.7	9.27	259
302	1489.3	8.68	293
356	1486.1	7.62	346
427	1482.8	6.47	418
493	1480.2	5.51	485
535	1478.8	5.05	528
573	1478.1	4.74	566
609	1477.5	4.49	601
653	1477.1	4.21	648
768	1477.4	3.78	762
855	1478.0	3.56	849
952	1478.8	3.36	946
1107	1479.9	3.01	1101
1267	1481.4	2.70	1265
1485	1483.9	2.42	1484
1644	1485.9	2.26	1646
1896	1489.2	2.03	1900

j. **Quality of XBT Data**

(1) Comparison of Temperature Profile Data

As part of the environmental data collection efforts aboard MARYSVILLE, expendable bathythermographs (Sippican Model T7) were taken at each SVP station, and one between each station. It was recognized fairly early in the cruise that some of the XBT traces were erroneous or unreliable. In obvious cases, another unit was launched. The retention of faulty traces and accumulation of other information was begun only later in the program at sea. Thus, in addition to processing the SVP data, a comparison between the temperature-depth profile indicated by the sensor in the SVP package and those from the XBT's was undertaken as time permitted. The following paragraphs present a brief description of the procedures used, some conclusions and some recommendations.

(2) Method

The instrument package used for the sound velocity profiles is described earlier in this section. Some of its features should be emphasized here.

The temperature sensor was calibrated both before and after the experiment to within 0.01°C at Woods Hole. Depth determinations were made using an inverted echo-sounder. Depth at discrete intervals was computed by a summation process using the average of interval sound velocities, read from the sound velocimeter, multiplied by the one-way travel time of the sounding pulse in that interval. It is estimated that depths used for these comparisons are accurate to within 4 meters in 6000 meters (see page 82 of this report).

(3) Tests Made

The "standard" Sippican system was used as modified for the deep (750 meter) XBT's. In addition to calibrating the recorder when installed at Pearl Harbor, the following tests were conducted at sea in order to insure that the errors were not in the XBT recording instrument:

(a) Using the test canister, calibration checks were within tolerances noted in the operating manual.

(b) Leakage tests of the cable to launcher using a 100 megohm "megger" showed leakage resistance was above 100 megohms.

(4) Results and Discussion

Although there were temperature differences between the telemetered data and the XBT data for subsurface depths, the XBT, SVP, and bucket thermometer surface temperatures agreed satisfactorily in all but two cases noted below.

There were inevitable time differences between the XBT drop and SVP lowering since the XBT drops were made immediately prior to or following the SVP cast for fear of entangling the wire and cable. For this reason, differences in temperature profile detail in the first two or three hundred meters, where internal waves may have displaced the isotherms, were not called faulty. Quite often the agreement between the two methods was excellent in this depth range.

Comparisons of XBT records from drops where SVP lowerings were not made were carried out using an average of readings from SVP stations bracketing the XBT station.

There were essentially two categories of faulty XBT records: the first included recordings of very ragged and/or suddenly ter-

Table B-XXVI
XBT's Taken Aboard MARYSVILLE
During PARKA I (U)

Degree of Reliability*	XBT Cast Numbers	Total Number	Percent of Total
Good or very good	1, 3, 5, 19, 25B, 26	6	12
Probably good	2, 4, and one unnumbered	3	6
Good to 700 m	13, 17, 25A	3	6
Good to 600 m	7, 18, 22, 33	4	8
Good to 500 m	6, 9, 10, 11, 21, 23, 31, 34	8	16
Good to 400 m	8, 12, 24, 30A, 30B	5	10
Good to 300 m	16, 20	2	4
Bad below surface	14, 15, 27, 28, 29, 32†, plus nine unnumbered units	15	30
No records saved, but presumed to be bad		4	8
	Total	50	100%

*Good implies agreement closer than about 1/4 degree. The largest error noted was about 3°C at 750 meters at SVP station No. 13.

†No. 32 read low initially, then correctly at depths greater than 400 m.

minated temperature vs depth traces; the second, less obvious, involved a temperature error at depths below the surface, the error increasing gradually at greater depths. Although there were several records in the first category, the second accounted for the majority of bad casts (Table B-XXVI).

(5) Conclusions and Recommendations

The agreement between the bucket thermometer and the XBT surface readings is within 0.1°C in all but the first cast. However, it is our belief that at least half of the XBT's used here showed sufficient deviation at the greater depths to make them unsatisfactory for oceanographic research purposes.

It is recommended that a careful study be made of the XBT records from other vessels where independent temperature sensors were also employed. It is further recommended that additional comparison studies be made using reliable depth and temperature sensors and a statistically significant number of XBT's.

It is suggested that electrical leakage involving the submerged wire may be responsible for the majority of the faulty traces.

12. MPL Oceanographic Operations

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Marine Physical Laboratory
Scripps Institution of Oceanography

a. General

M/V PACIFIC APOLLO was equipped to take environmental oceanographic data during the PARKA I Experiment. The following is an outline of this work. The location and time of the sound velocity profile casts and the bathythermographs were essentially as outlined in the operation orders for environmental studies.

b. Equipment

The following equipment was used aboard PACIFIC APOLLO:

(1) Expendable bathythermographs to 750 meters with a Sippican R-467A system.

(2) Sound velocity profiles to 4000 meters.

(a) ACF Industries TR-4B velocimeter.

(b) Vibrotron depth gauge, model 8150, 0-7500 psi.

(c) Western Gear OWH-50 oceanographic winch.

(d) Inboard readout: Hewlett-Packard 5214L preset counters, Hewlett-Packard 562A digital printer, monitoring oscilloscopes.

(3) Echo sounding with a hydrophone mounted on the SVP instrument package. The output from an explosive sound source was recorded on a Tektronix memory oscilloscope, type 564.

(4) Sea surface temperature with a bucket thermometer at each 2-hour interval.

(5) Wind direction and force, sea state information at each 2-hour interval.

c. Event Log (all times in GMT) (U)

From: Date	Time	Location	To: Date	Time	Location	No. XBT	No. SVP
Along the track (157°50'W)							
14 Aug.	2300	27°30'N	20 Aug.	1200	33°36'N	29	10
Suspended operation, started return to FLIP							
21 Aug.	0000	32°46'N	22 Aug.	1800	36°00'N	8	4
22 Aug.	1800	36°00'N	25 Aug.	0600	27°20'N	10	4
Stopped operation to reposition FLIP							
27 Aug.	0000	27°23'N	28 Aug.	1200	22°30'N	8	2
Returned to Honolulu for engine repairs							
30 Aug.	2100	23°00'N	1 Sept.	0000	27°12'N	6	2
1 Sept.	0000	27°12'N	2 Sept.	1000	22°30'N	7	4
2 Sept.	1000	22°30'N	4 Sept.	0600	27°09'N	14	5
Moved to longitude 158°38'W							
4 Sept.	0800	27°01'N	4 Sept.	2000	29°00'N	13	0
Moved to longitude 158°15'W							
4 Sept.	2300	29°00'N	5 Sept.	1500	27°01'N	13	4
						108	35

d. Operation Notes

During the second SVP cast the cable developed a short at 2000 meters. The cable was cut at this point which limited all future casts to 4000 meters.

The depth gauge furnished by USNUSL flooded on a test lowering. The flooding was caused by a defective pressure connector. The instrument could not be repaired or recalibrated with the facilities on board. The backup MPL depth gauge was used on all lowerings.

e. Depth Gauge

The MPL variable frequency depth gauge is a 0-7500 psi Vibrotron with a sensitivity of 4.344 meters per Hz. Limited temperature sensitivity information was at hand.

The temperature sensitivity was approximately 0.4 Hz/°C.

The thermal time constant was approximately 14 minutes.

f. SVP Casts

The SVP casts were made as follows:

Cable rates	0 to 46 meters	0.5 m/sec
	46 to 460 meters	1.0 m/sec
	460 to 4000 meters	1.85 m/sec

Data were recorded during both the lowering and the raising of the instrument. The depth gauge frequency output at the start of the cast was used as a zero point for "down" data. The frequency output at the end of the cast was used as a zero point for "up" data.

The Hewlett-Packard counters were used with a time base that would yield a depth directly in meters and a sound velocity in meters per second. The counting times were approximately 4.5 seconds. Data were recorded on the digital printer at the end of each data count.

As many data points as were necessary to describe the sound velocity profile were plotted from the digital printer output.

13. Bathymetric Charts and Survey Ship Tracks

R. J. Van Wyckhouse
Undersea Surveillance Oceanographic Center
Naval Oceanographic Office

a. General

The Undersea Surveillance Oceanographic Center (USOC) of the Naval Oceanographic Office has prepared bathymetric charts covering the PARKA I Experiment track. (Fig. B-54). Each chart covers an area several degrees North-South by two degrees East-West (Figs. B-55–B-89) with total coverage taking in the area from 22°N to 55°N and 157°W to 159°W.

They include only bathymetric data collected using Loran C electronic navigation or more precise positioning. These bathymetric charts therefore are not compiled from all available data; site surveys, tracks with poor navigation, and random track data were omitted. Only two sources of data were of sufficient quality and coverage to be utilized.

The most extensive data coverage in the area of interest was provided by the Loran C-controlled USC&GS-ESSA Project SEAMAP (Reference 1). Bathymetric data collected during the PARKA I experiment R/V ROBERT D. CONRAD using satellite navigation was the second data source. All SEAMAP and CONRAD tracks used to compile the 2° wide bathymetric charts are shown on the track charts (Figs. B-90–B-93). Only the more significant sea-floor topographic features can be delineated with any reliability because line spacing is approximately 12 miles or greater.

The bathymetric strip charts are constructed on a Mercator Projection. The contour interval on these charts is 100 fathoms and the depths are *uncorrected* for variations from the standard sound velocity of 4800 ft/sec. Nomograms based on Matthews' tables are provided in Figures B-94 through B-98 if corrected depths are desired (Reference 2).

b. **Instructions for Reading Depth Correction Nomograms**

The echo sounder is set to read depths directly on the assumption of a constant velocity of 800 fathoms per second in sea water. In 1939 Matthews showed that there were over fifty areas in the world ocean where sound velocity could be differentiated. In all but seven of these areas the correction factor is additive throughout the entire water column because the velocity of sound in water is greater than the assumed constant for the majority of the world ocean. The five Matthews' areas covered by these nomograms all require added correction factors applied to the uncorrected depths. An uncorrected depth in fathoms is read from the left side of the graph. This depth is then followed along the horizontal axis of the graph until it intersects the curved correction line. From the point of intersection the vertical axis is followed down until it can be read on the horizontal scale. This is the correction in fathoms to be added to the uncorrected depth to form the corrected depth.

c. **References**

(1) Elvers, D. J., Matthewson, C. C., Kohler, R. E., Moses, R. L.: Systematic Ocean Surveys by the USC&GSS Pioneer, 1961-1963, Operational Data Report C&GS DR-1, Fredericksburg Geomagnetic Center, Corbin, Va., Sept. 1967.

(2) Matthews, D. J.: Tables of the Velocity of Sound in Pure Water and Sea Water for Use in Echo-Sounding and Sound-Ranging, Hydrographic Department, Admiralty, London, 1939.

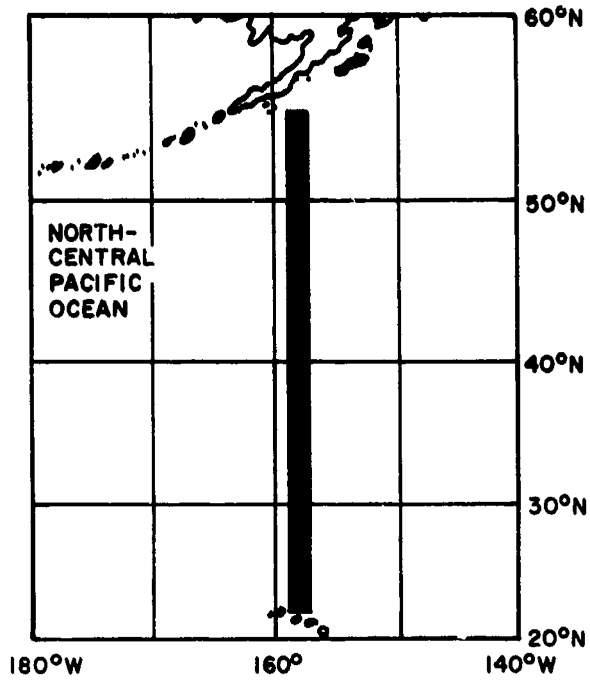

Fig. B-54 – Chart showing location of bathymetric strip charts (U)

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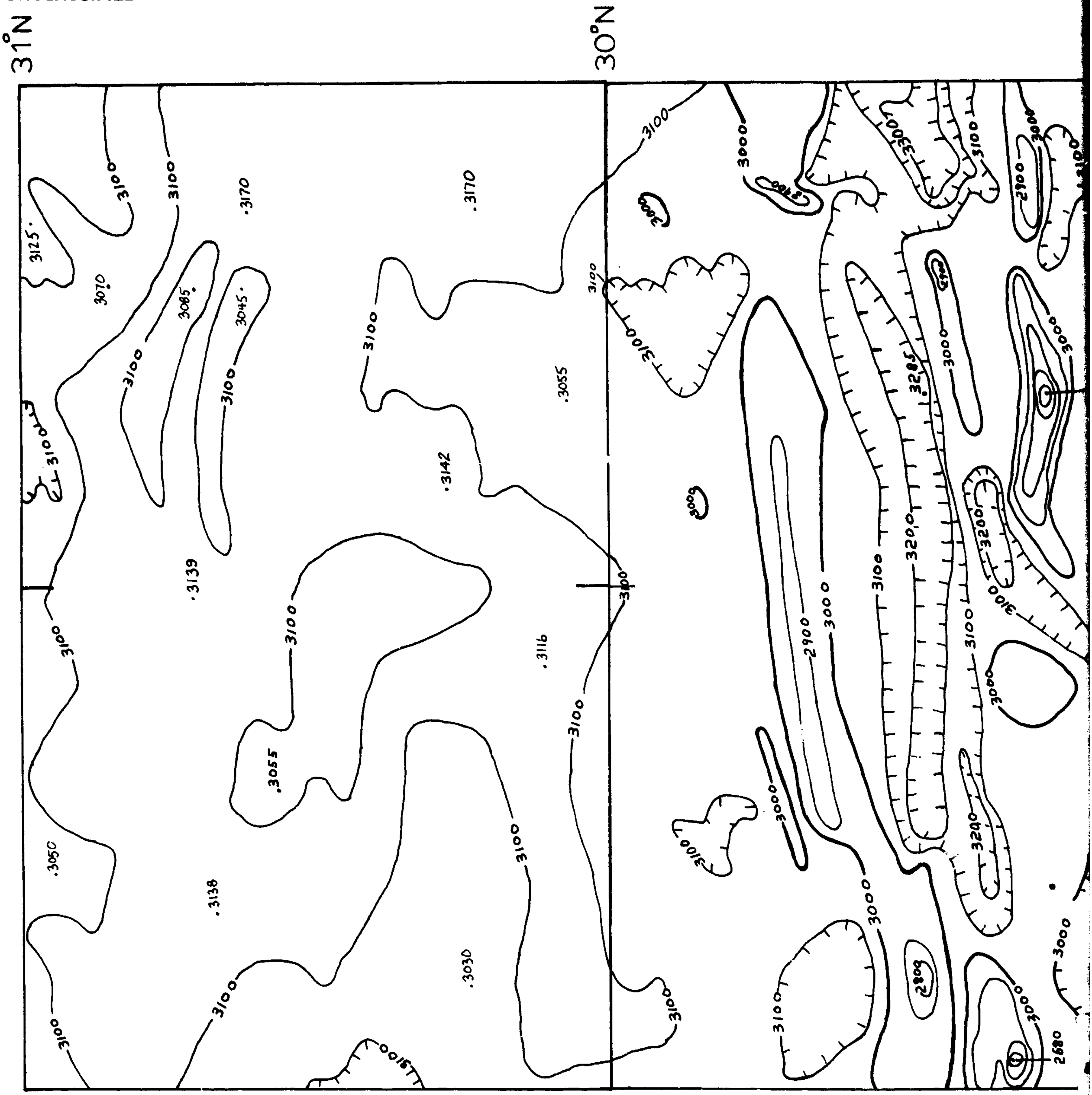
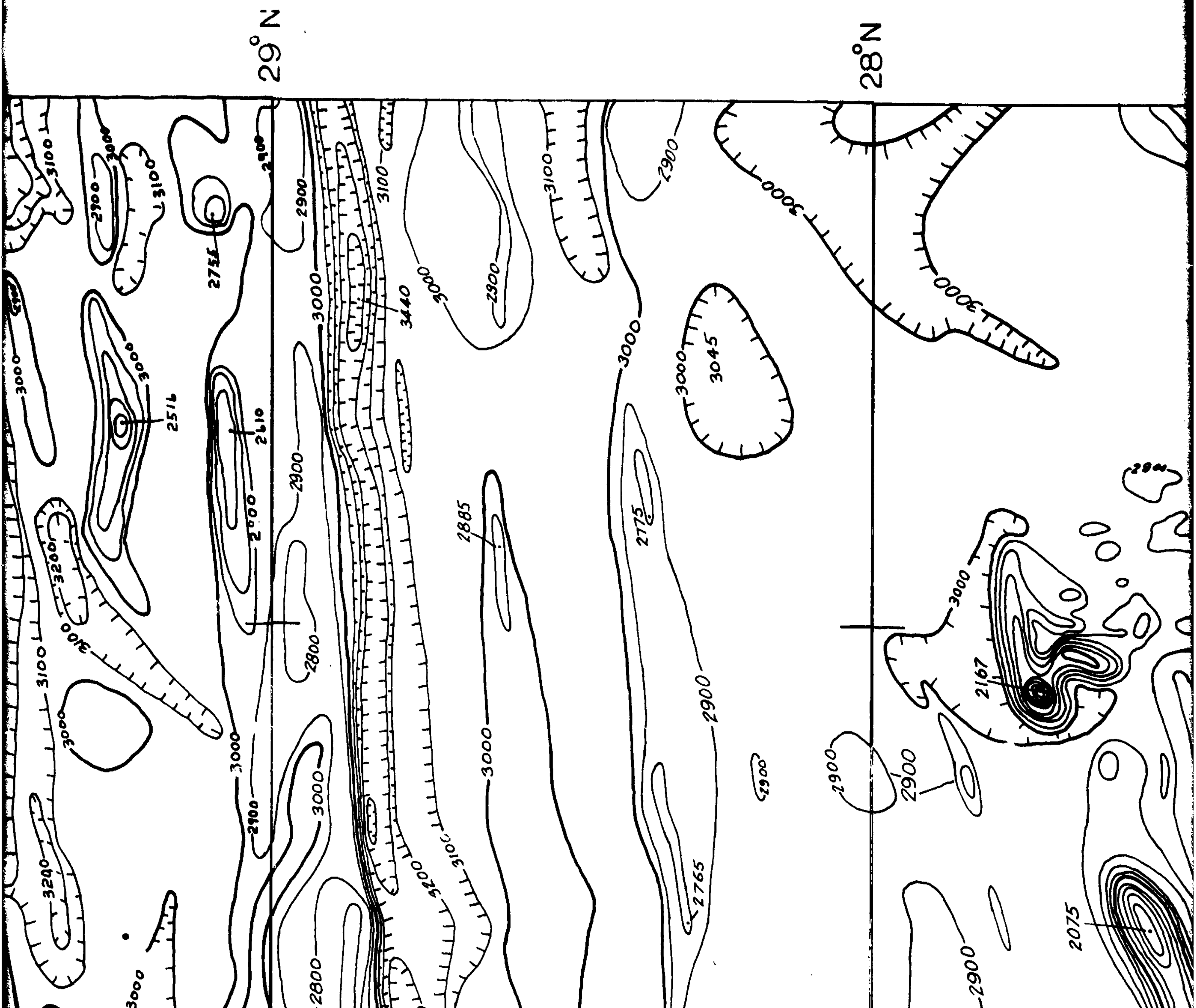


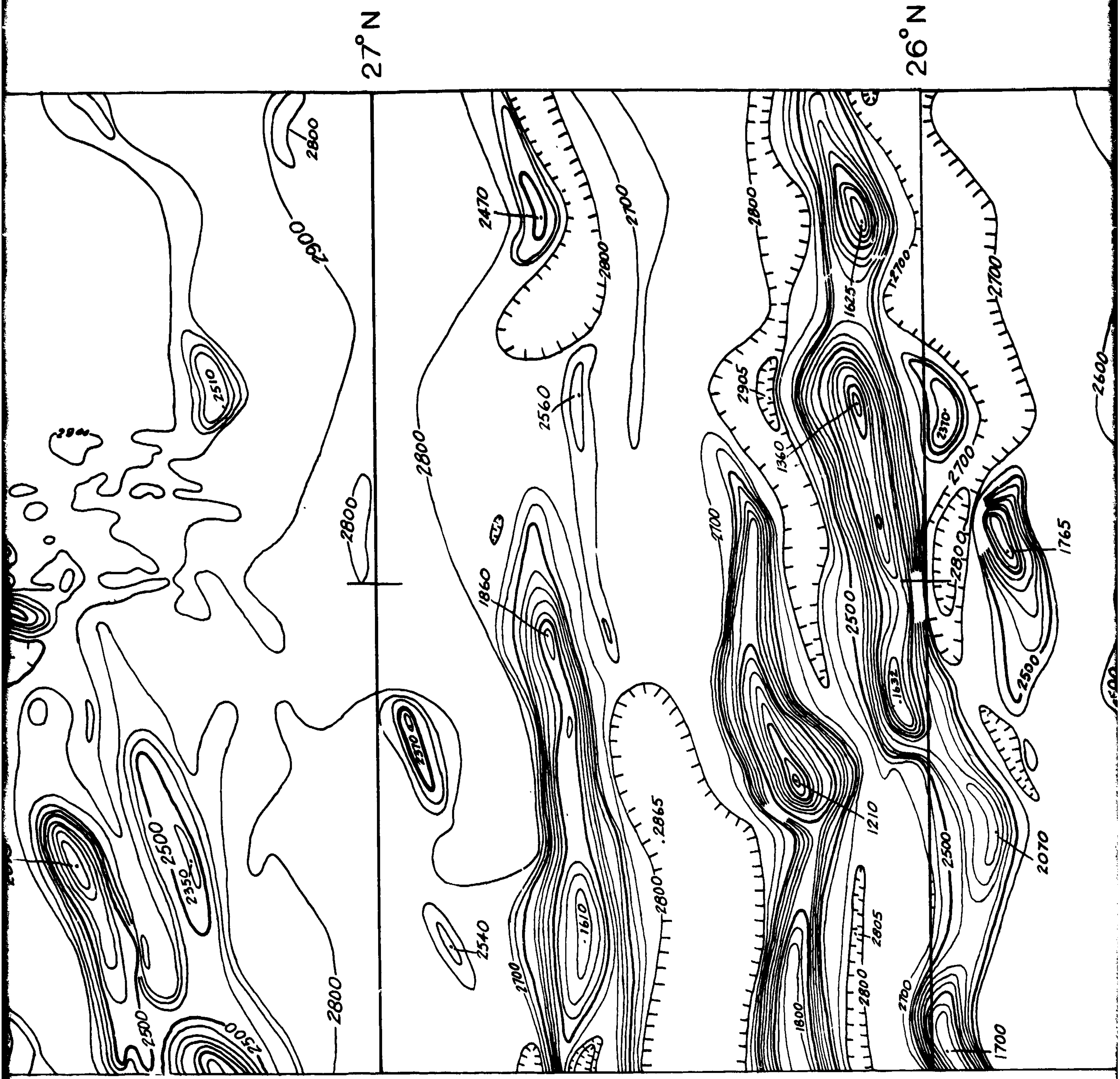
B-63

B-62

1


29° N
28° N
3100
2900
3000
2756
3440
3045
2516
2610
2885
2775
3200
2800
2167
2765
2075
2615
3300
2680

2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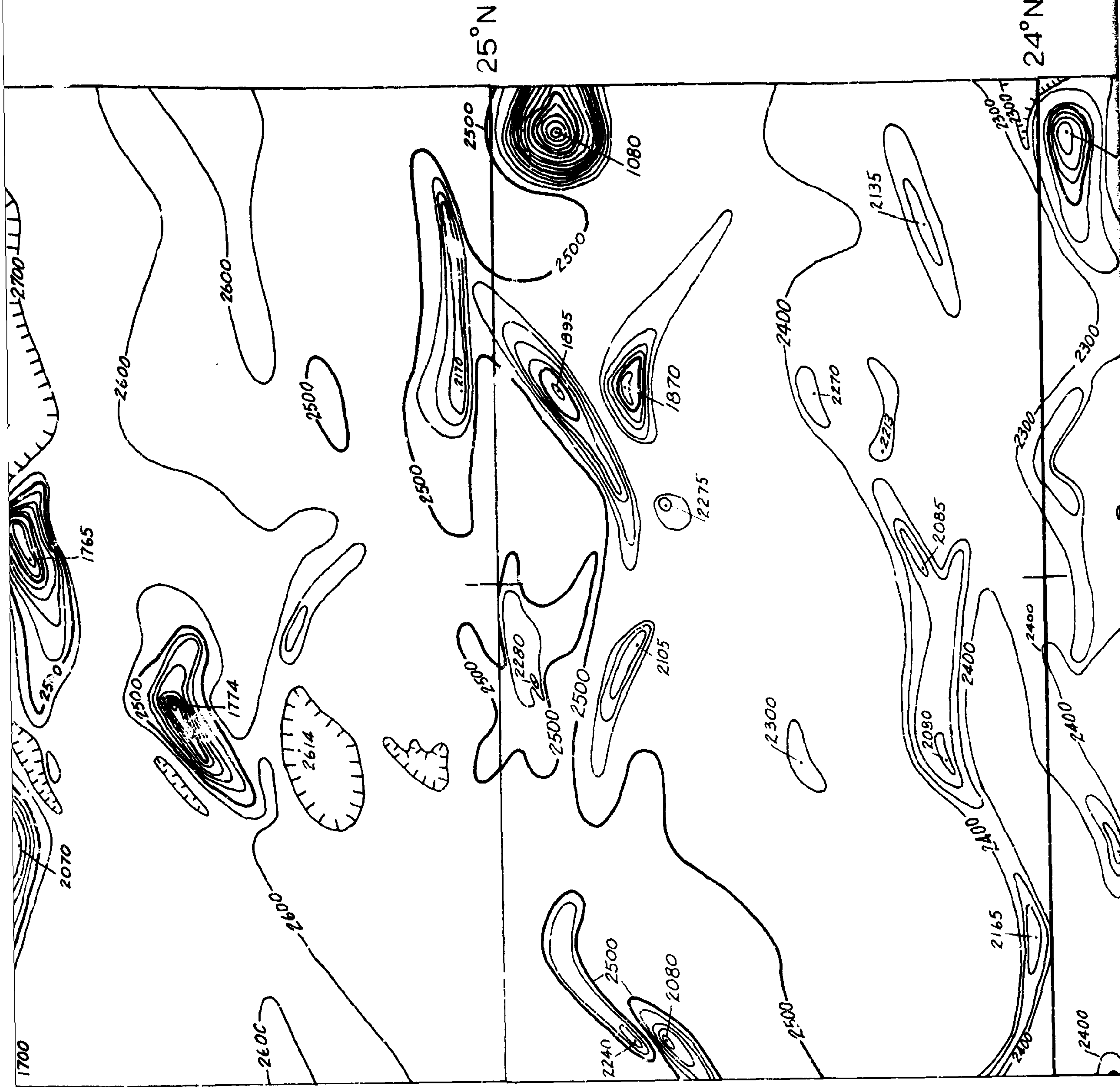
26°N
2800
2900
2510
2470
2700
2560
2800
1860
2310
2540
1610
2865
2800
2700
2500
2350
2500
2905
1360
1625
2700
2500
1210
1632
2805
1800
2370
1765
2500
2070
1700
2600

B-60

B-59

3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1080
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2400
2270
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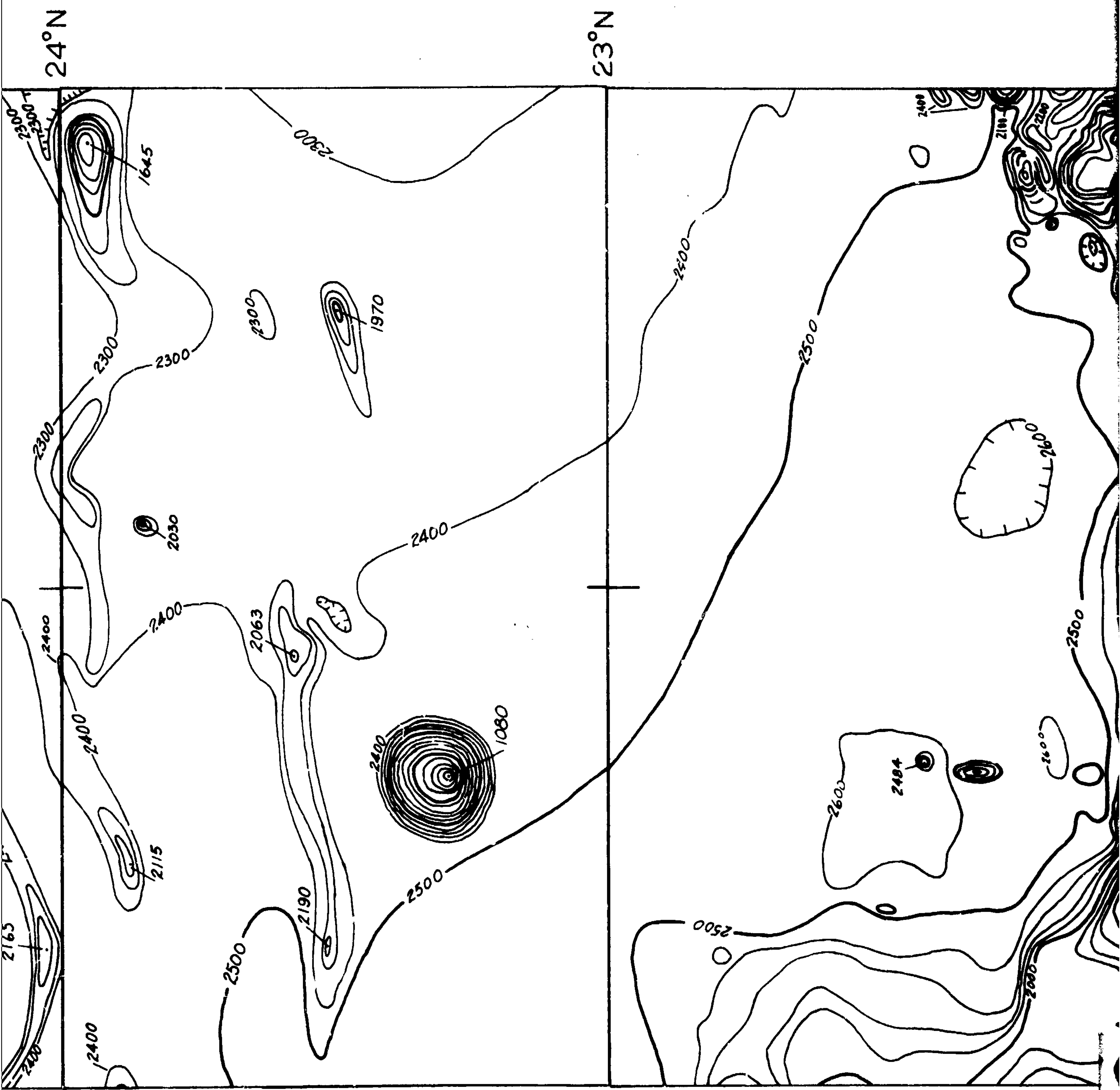
2085
2300
1774
2614
2280
2105
2070
2090
2165
2080
2240
1700

B-58

B-57

4

(Page 1



24°N
23°N
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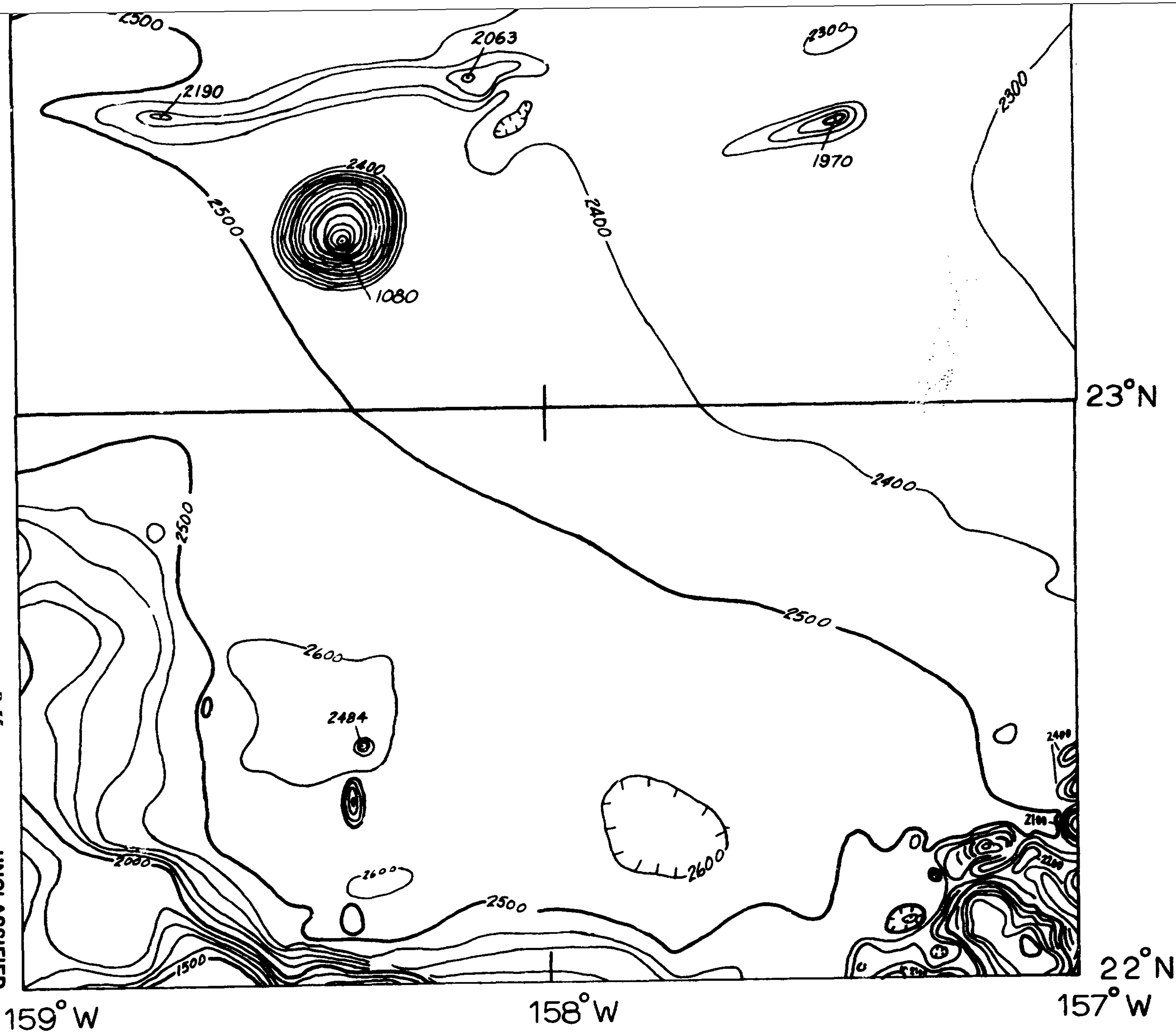
1970
2030
2063
1080
2115
2190
2165
2484
2300
2400
2500
2600

5



B-56

B-55

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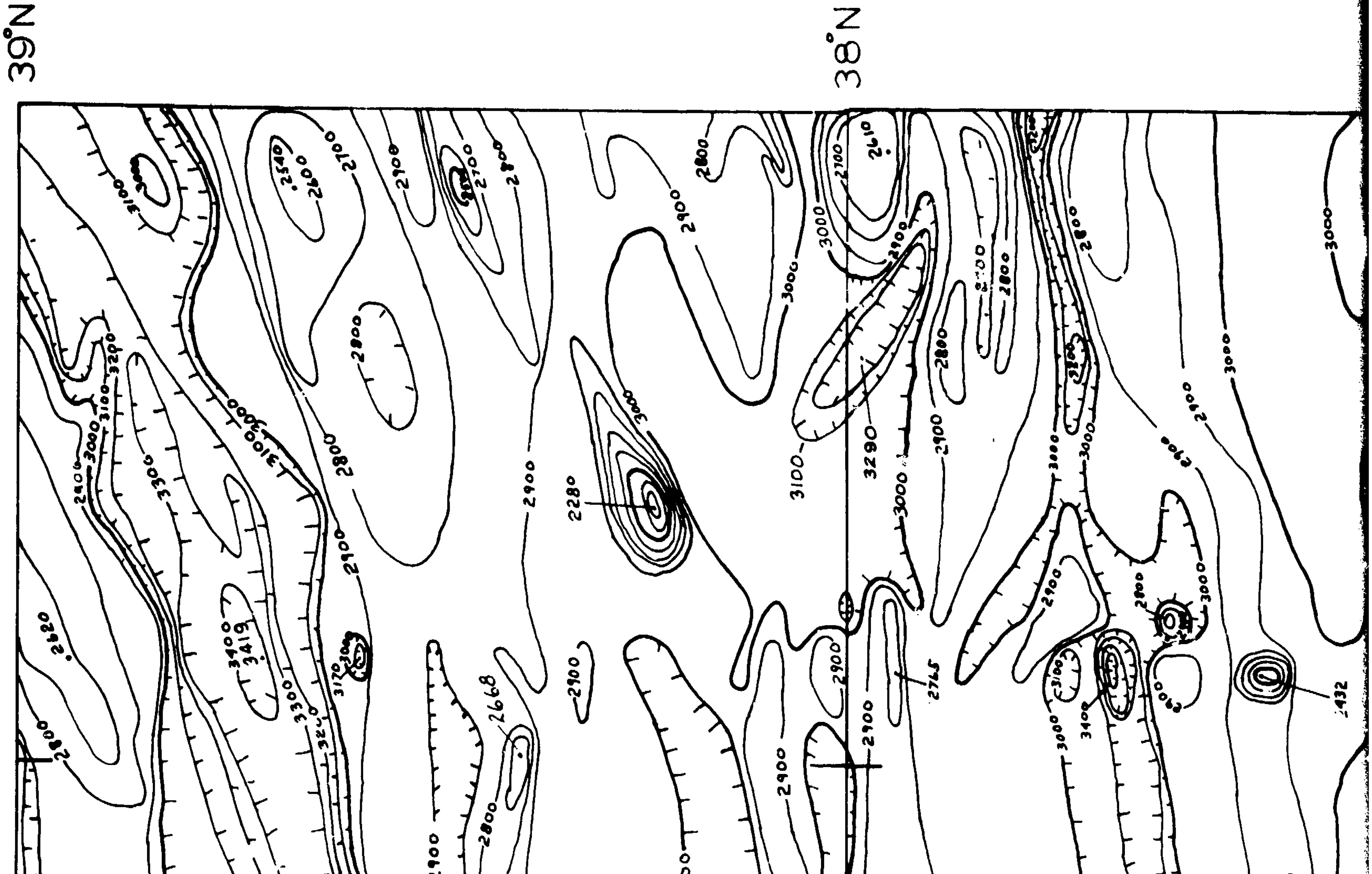
Figs. B-55 - B-63 – Two degree bathymetric strip chart (U)

16



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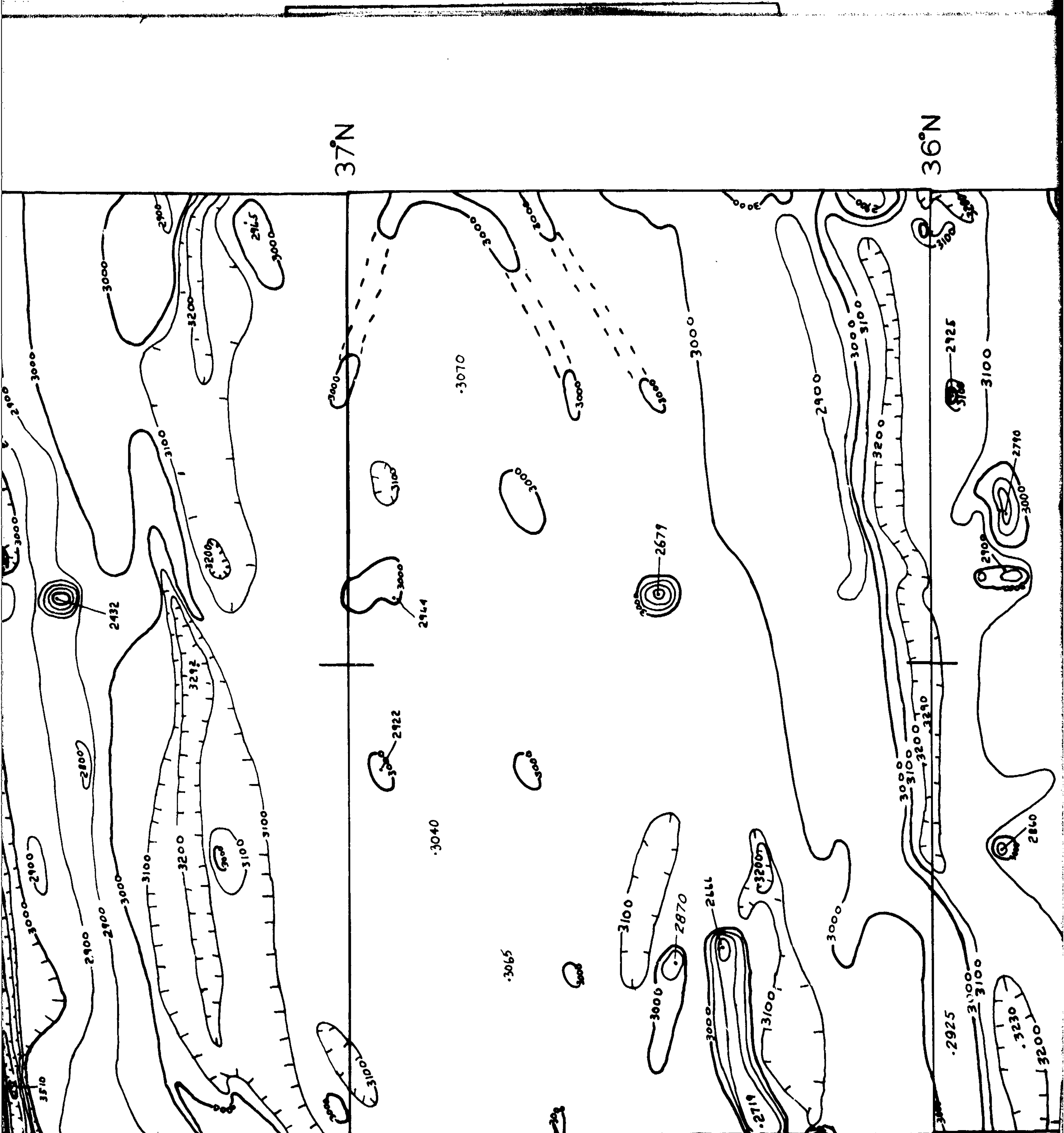
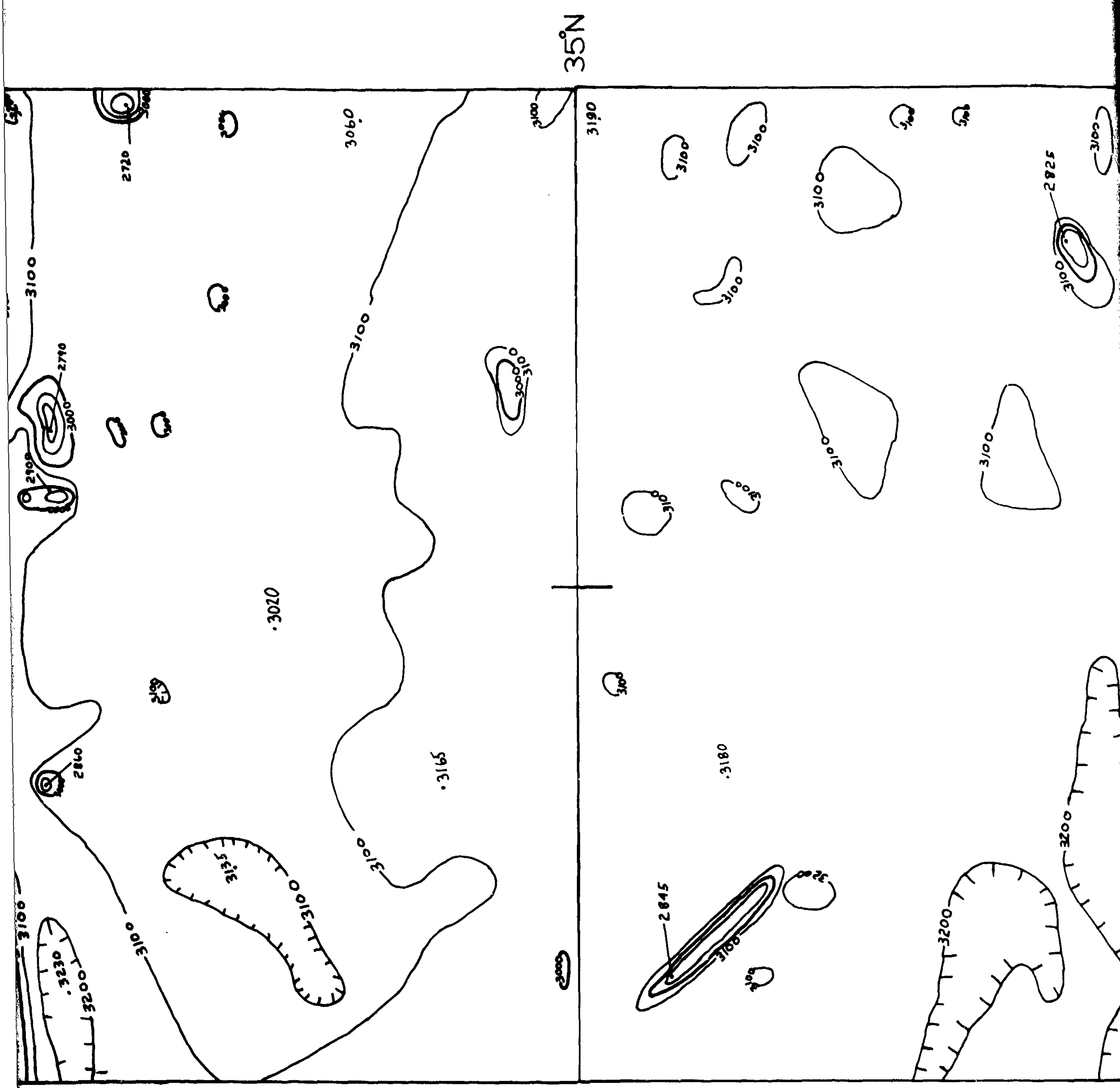


B-70

B-69


35°N
3100
3060
3020
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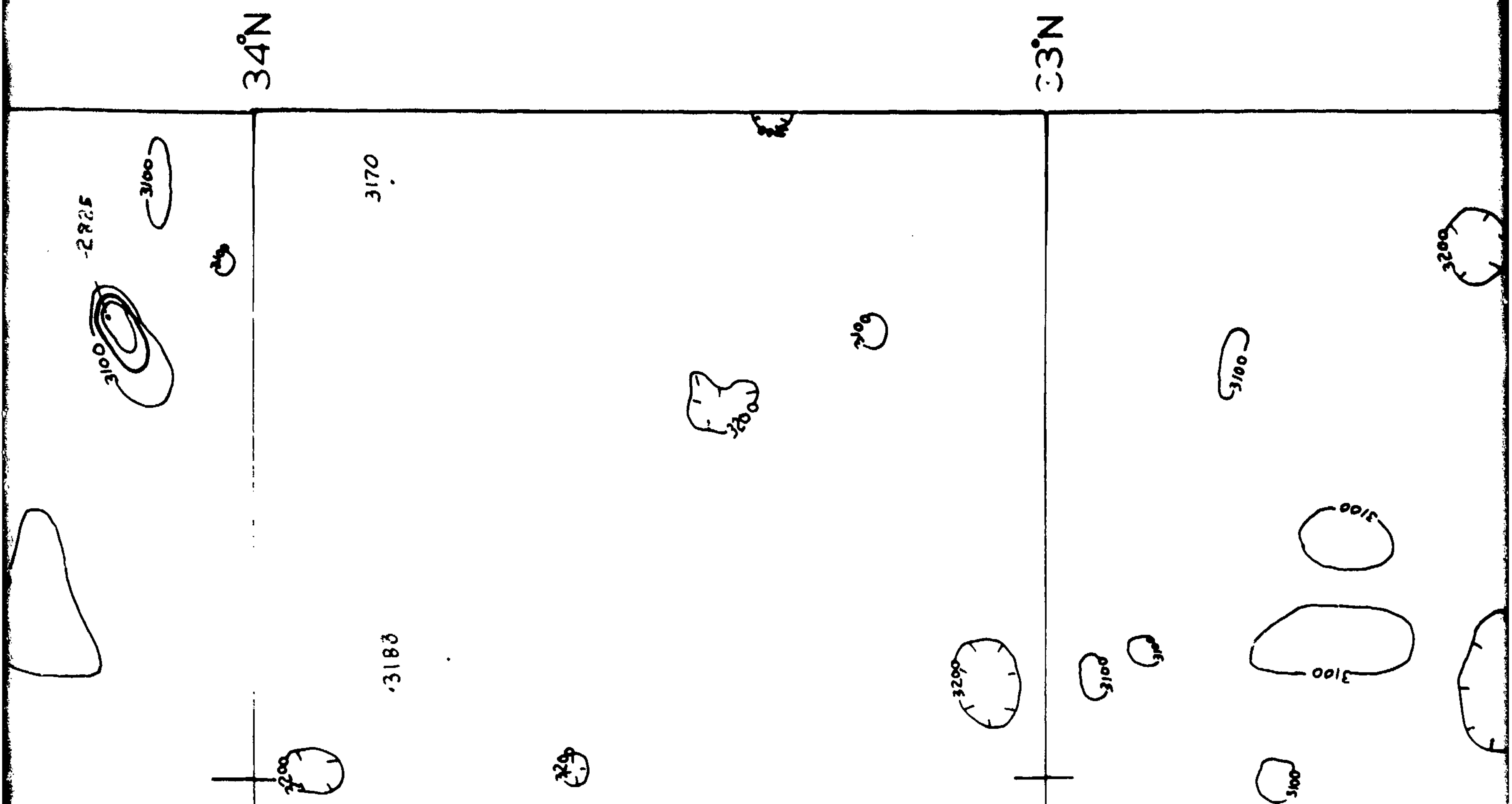
3135
3230
3200
2720
2790
2860
3190
3180
2825
2845

B-68

B-67

3



B-66

B-65

4

B-65

B-64

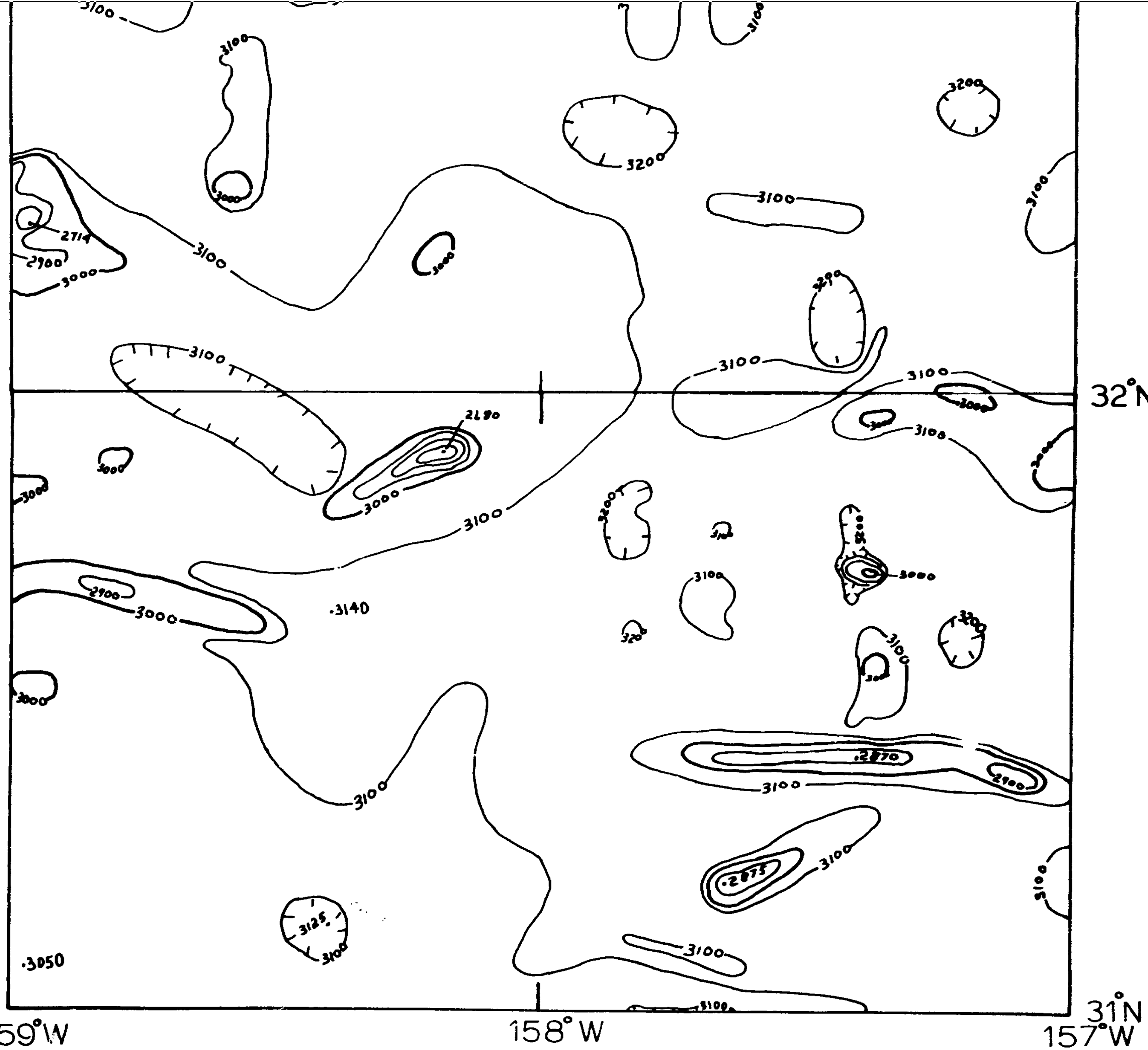


CHART 2

Figs. B-64 - B-71 — Two degree bathymetric strip chart (U)

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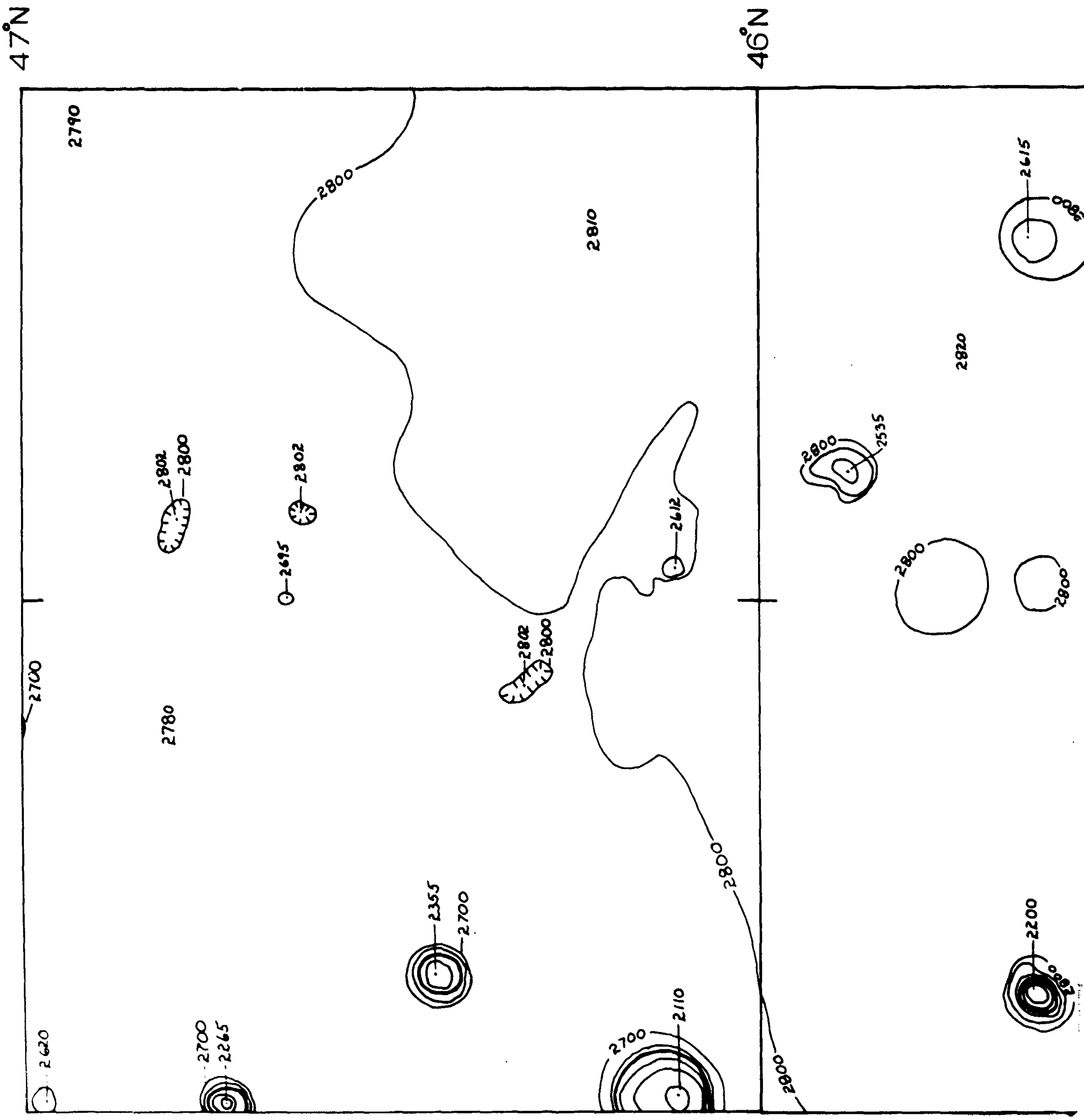
5



47°N
46°N
2790
2800
2810
2820
2615
2800
2535
2800
2802
2800
2802
2695
2612
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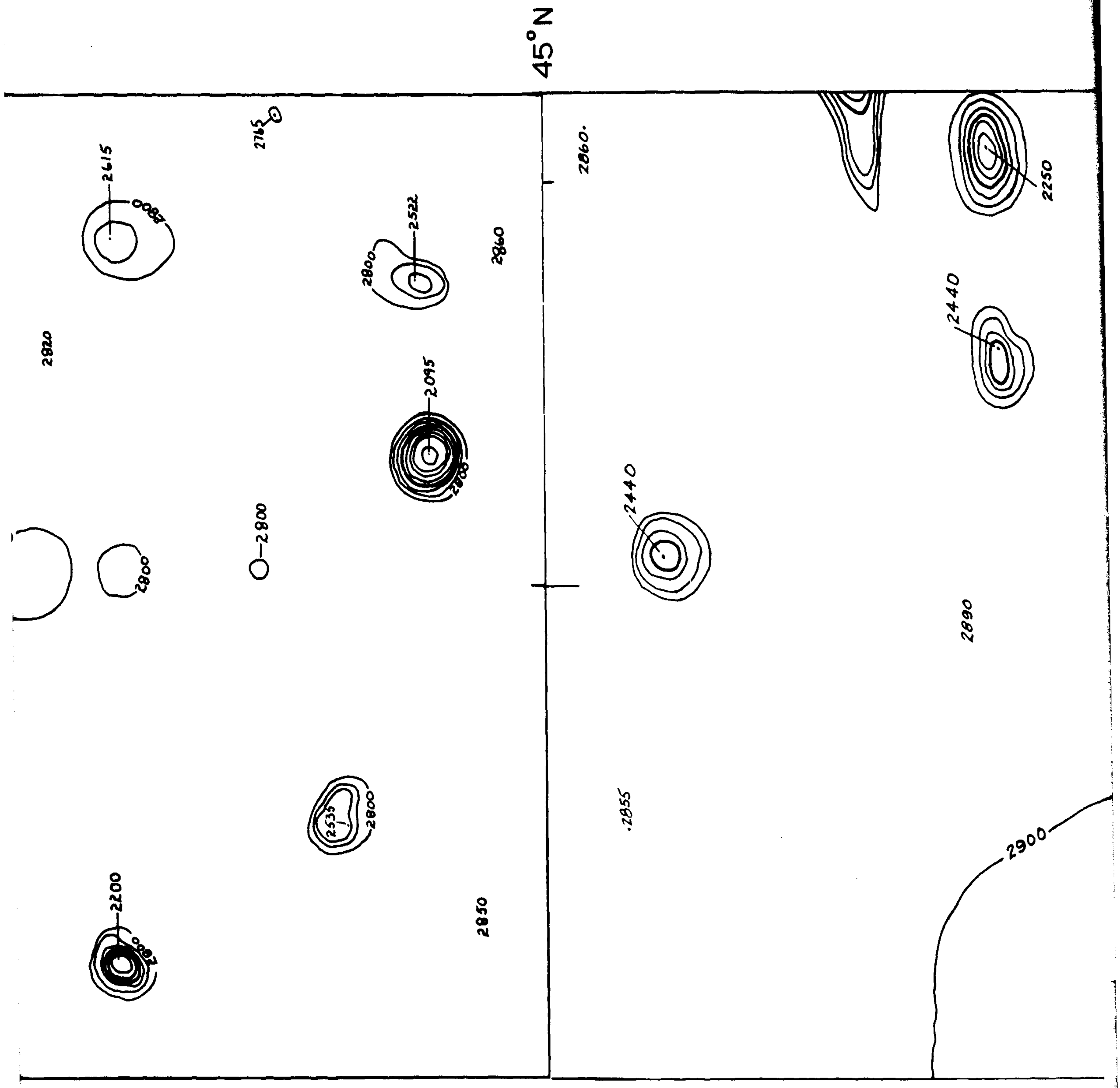
2620
2700
2265
2800


45°N
2765
2615
2800
2522
2800
2860
2820
2095
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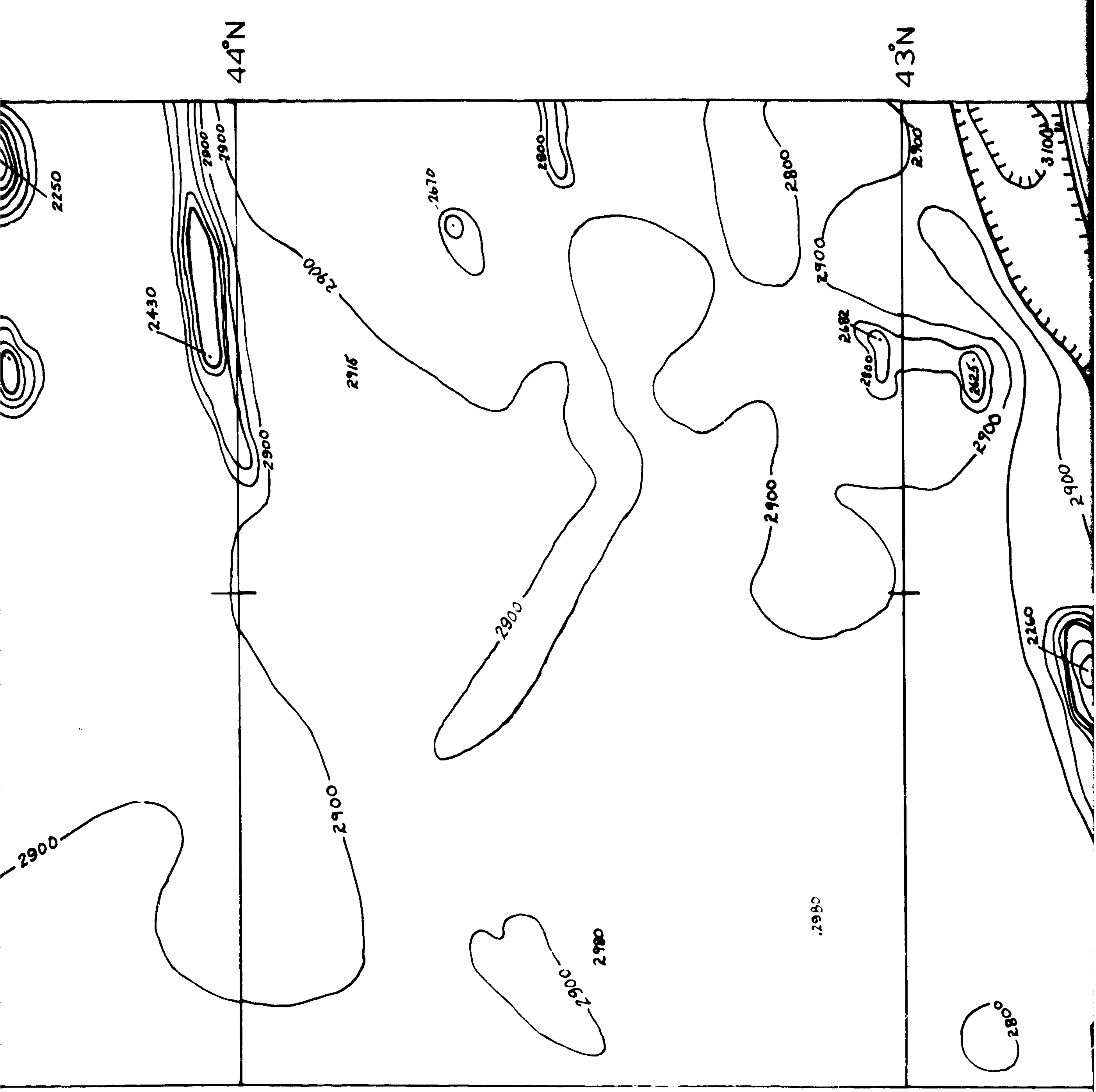
2855
2900

B-78 B-77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43°N
2250
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2900
2916
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2800
3100
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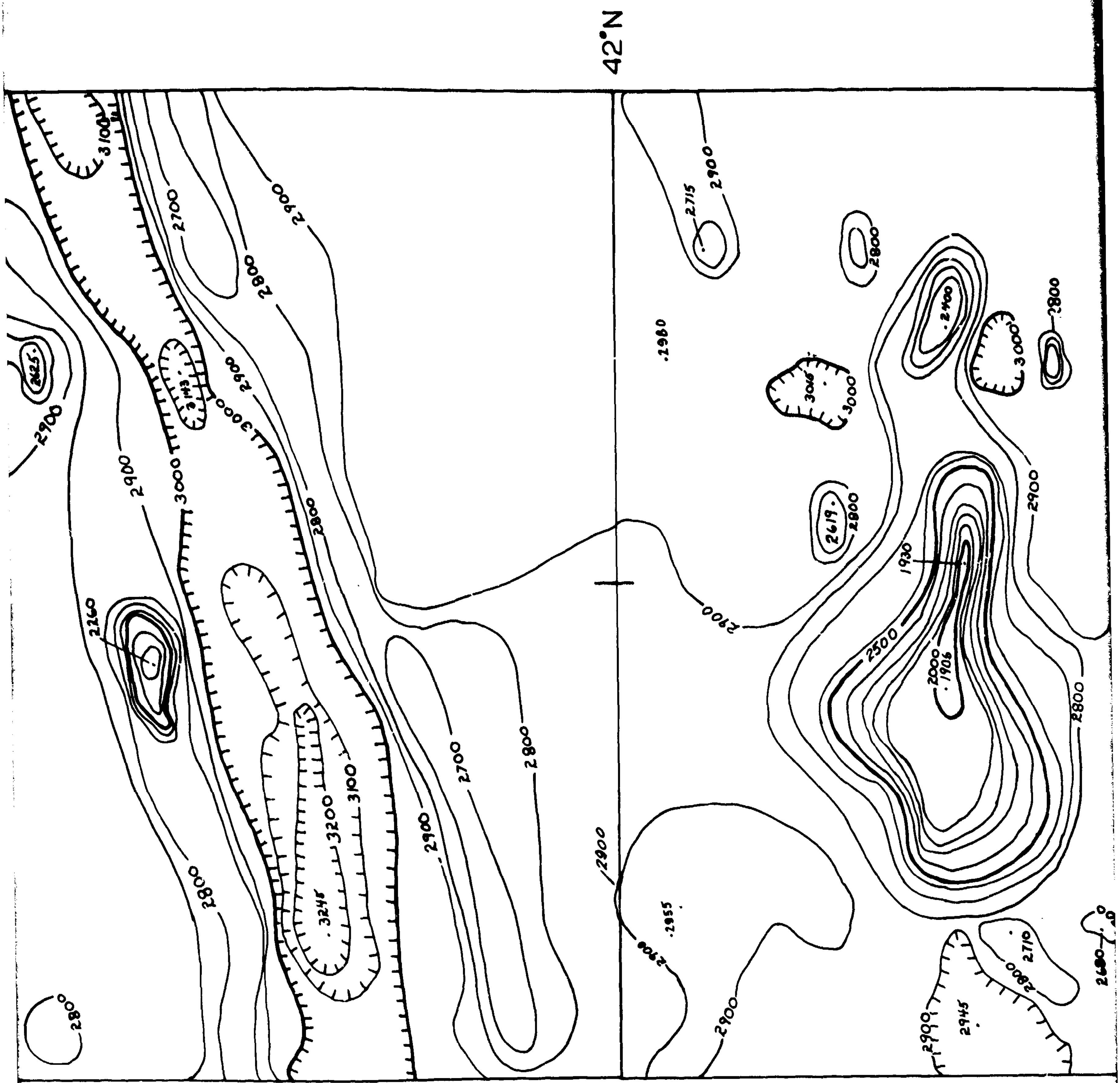
2625
2260
2980

3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3100
2700
2900
2800
2625
3143
3000
2980
2715
2400
3016
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1930
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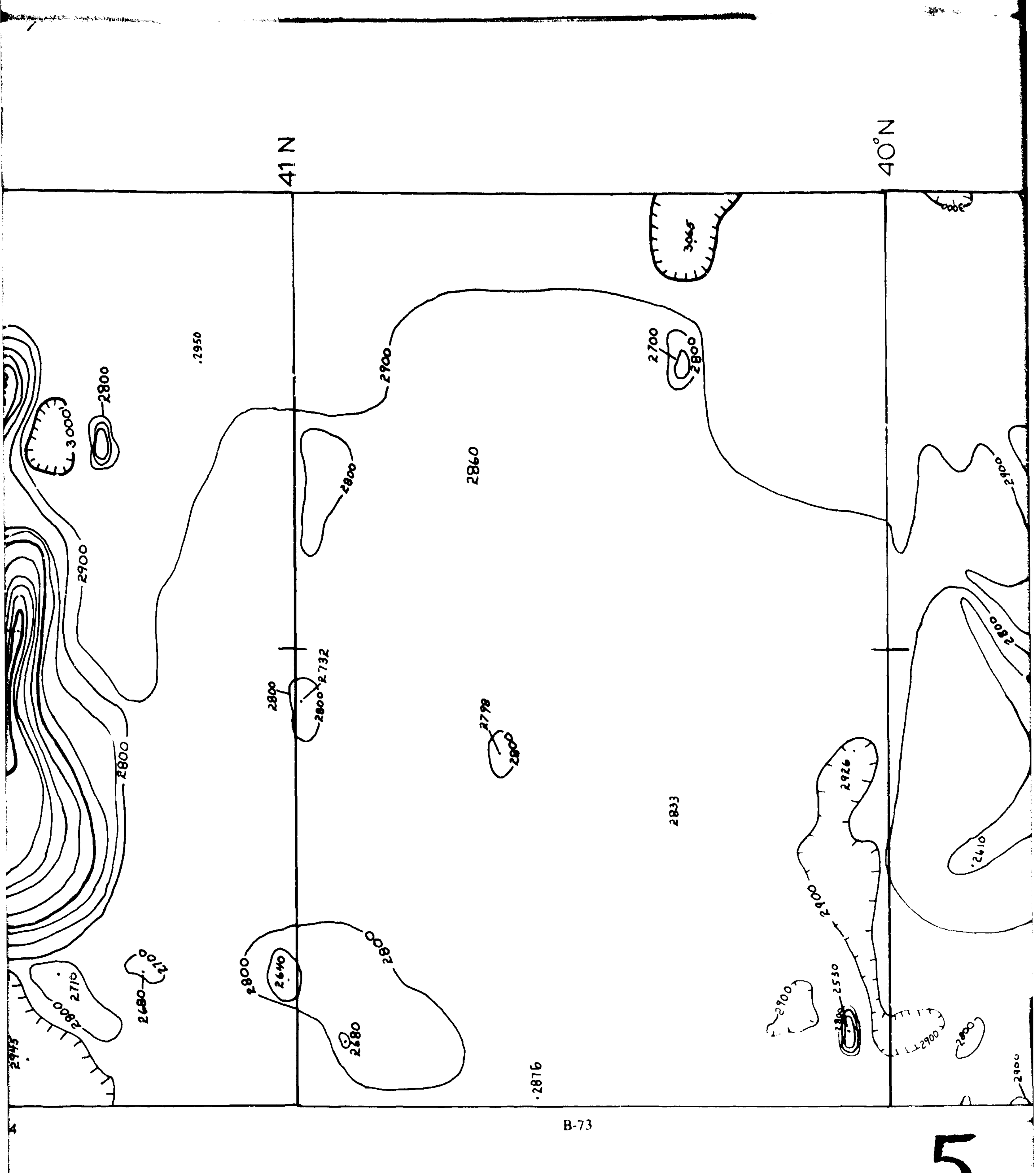
2000
1906
2260
3200
3100
3248
2955
2945
2710
2680

B-75

B-74

4


41 N
40°N
.2950
2800
3000
2900
2860
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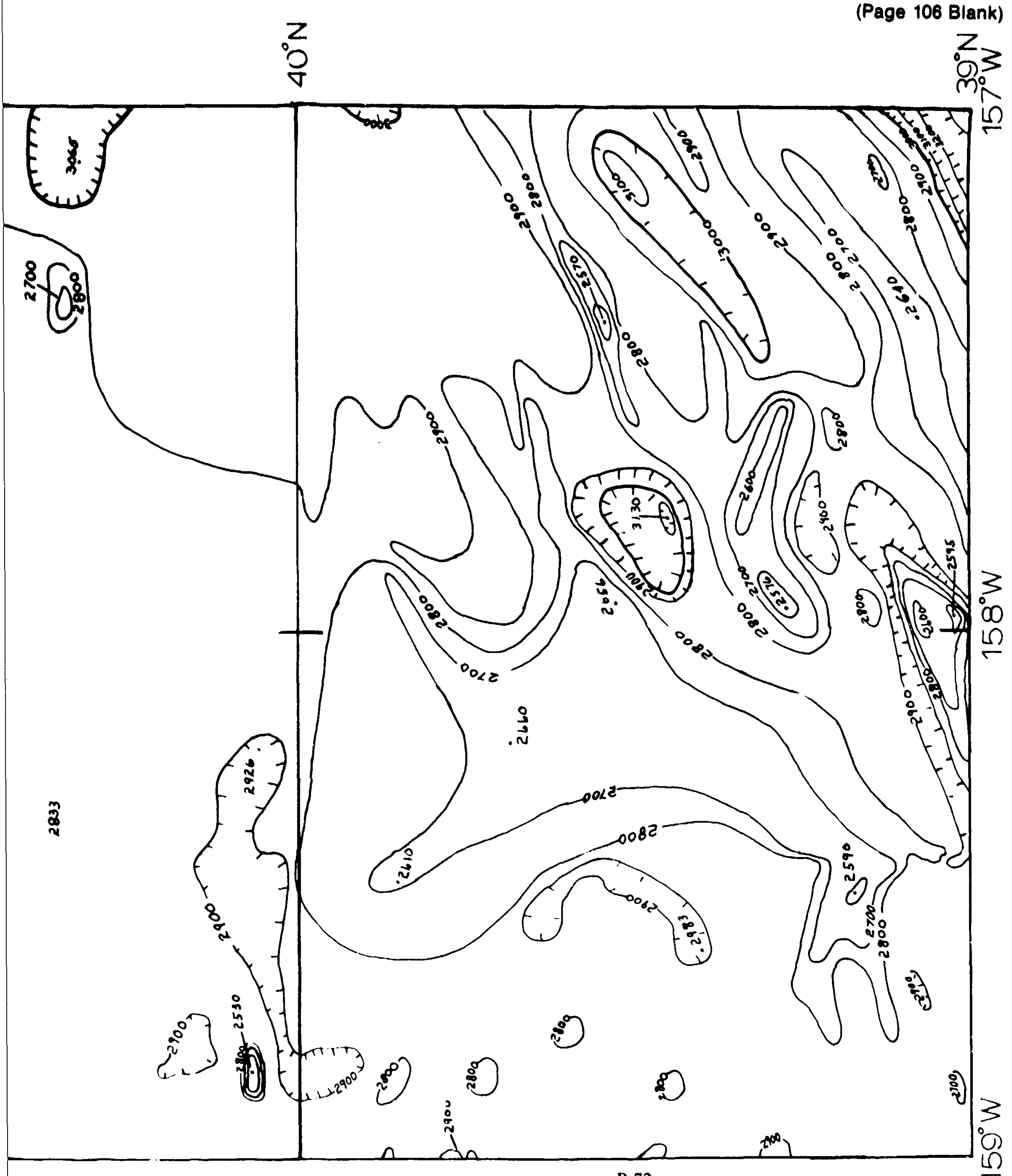
2945

5



Figs. B-72 - B-79 — Two degree bathymetric strip chart (U)

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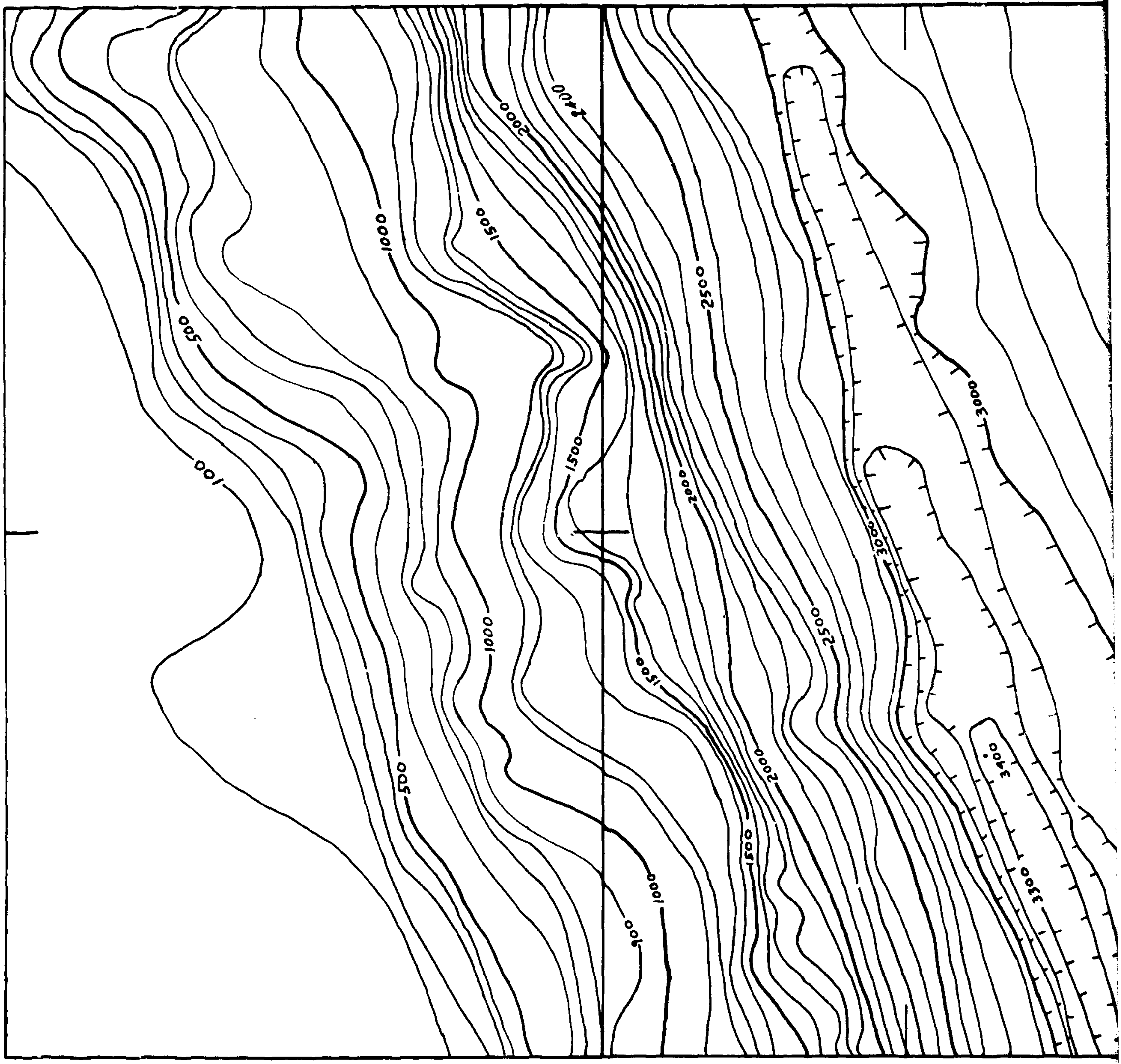
55°N

54° 20'N



B-89

B-88

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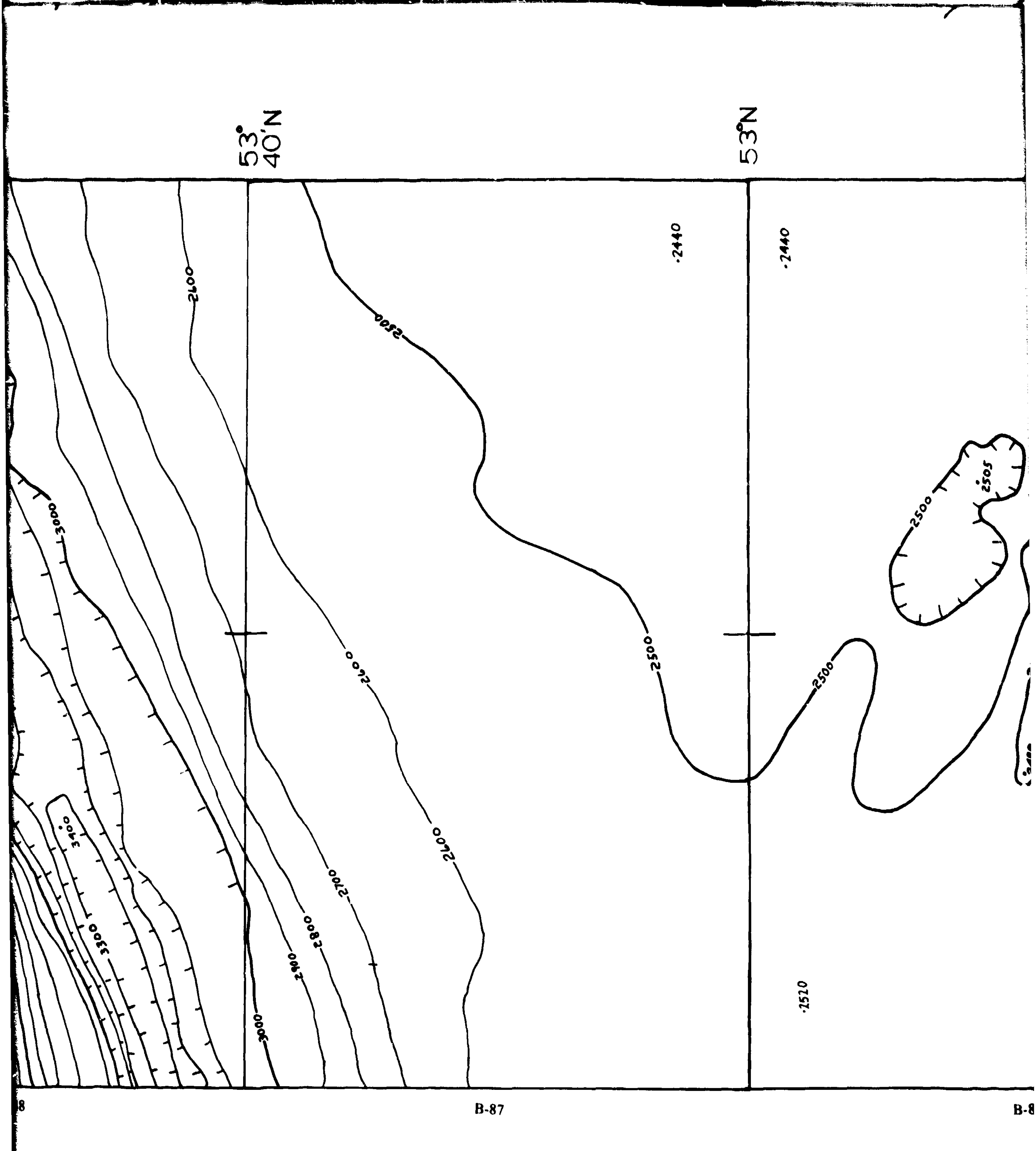
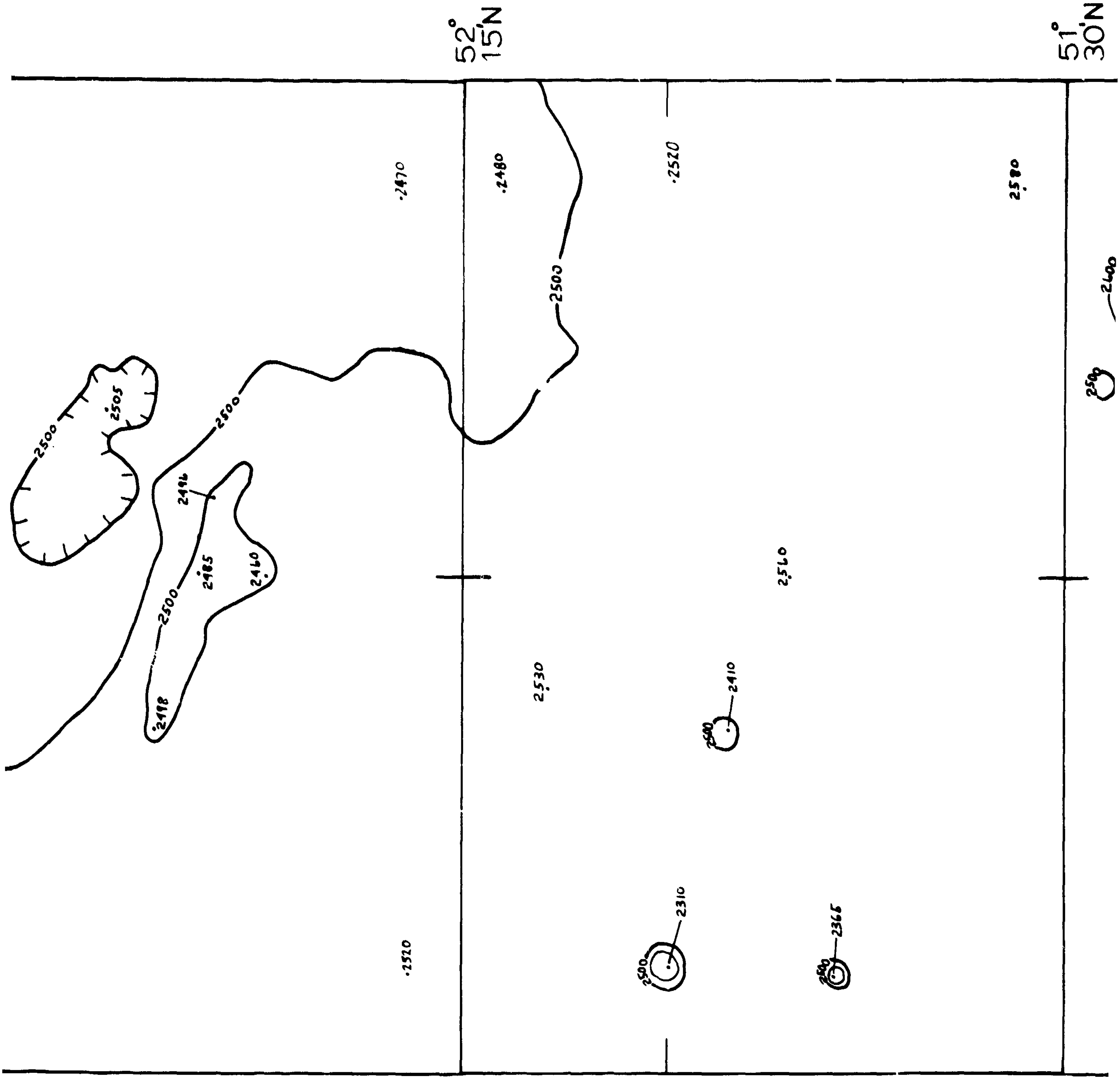

53° 40'N
53°N
2440
2440
2600
2500
3000
2505
2500
2500
2500
2700
3900
3300
2600
2700
2800
2900
3000
2520

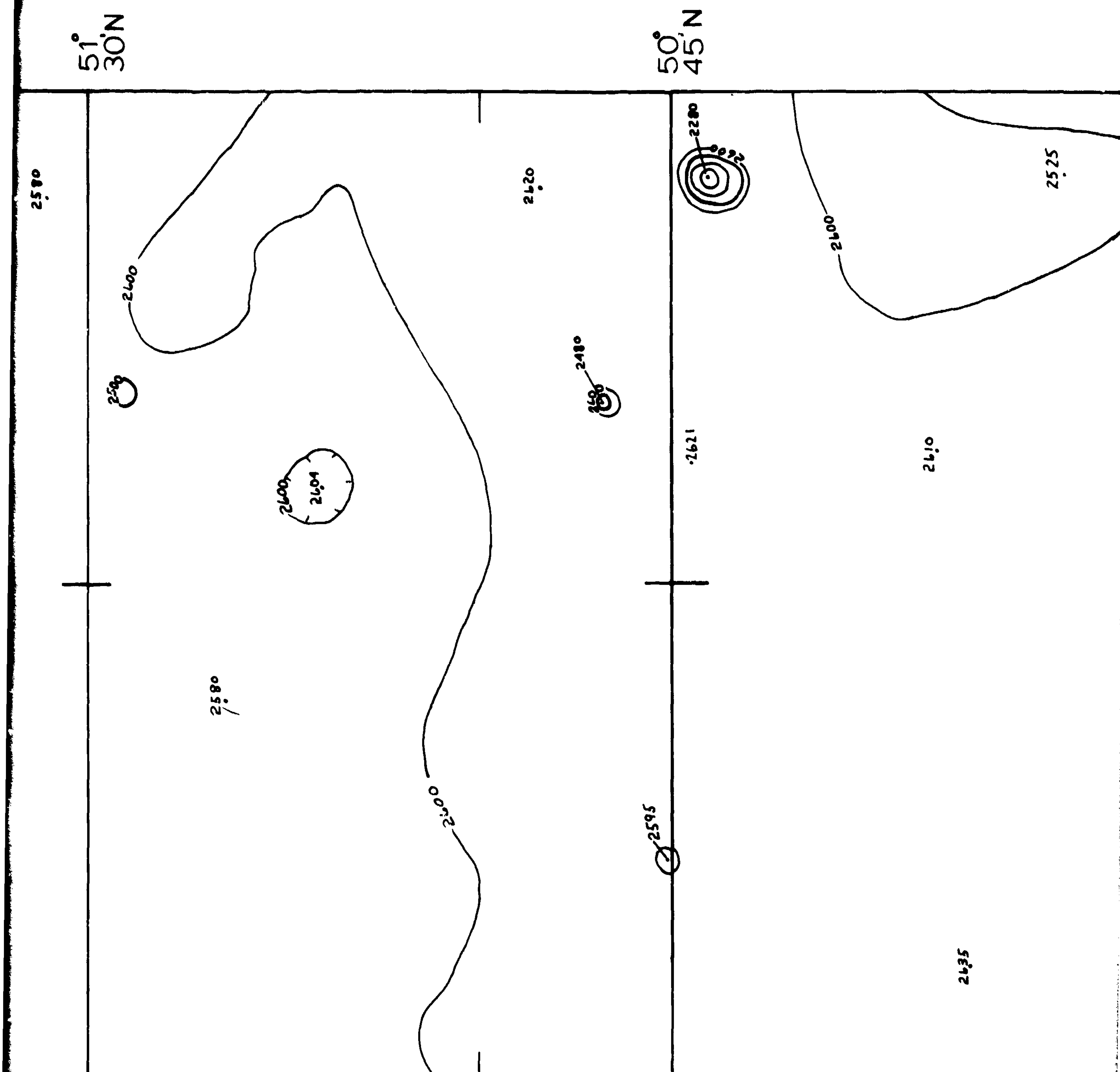
2


52° 15'N
51° 30'N
2470
2480
2520
2580
2600
2500
2505
2496
2485
2460
2498
2560
2530
2410
2310
2365
2520

B-86

B-85

3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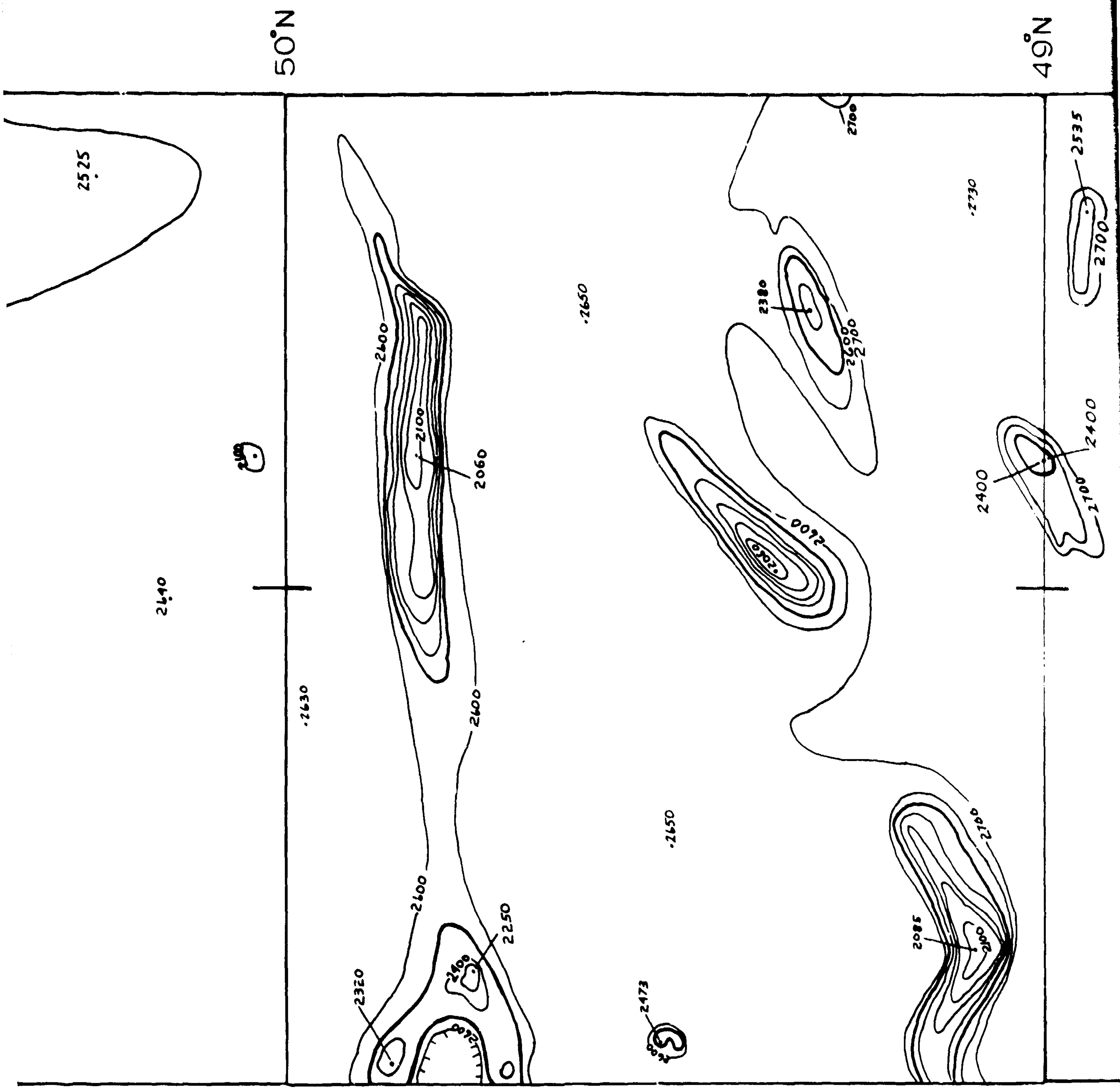
50° 45'N
2580
2600
2620
2280
2600
2525
2600
2480
2621
2610
2600
2604
2580
2600
2595
2635

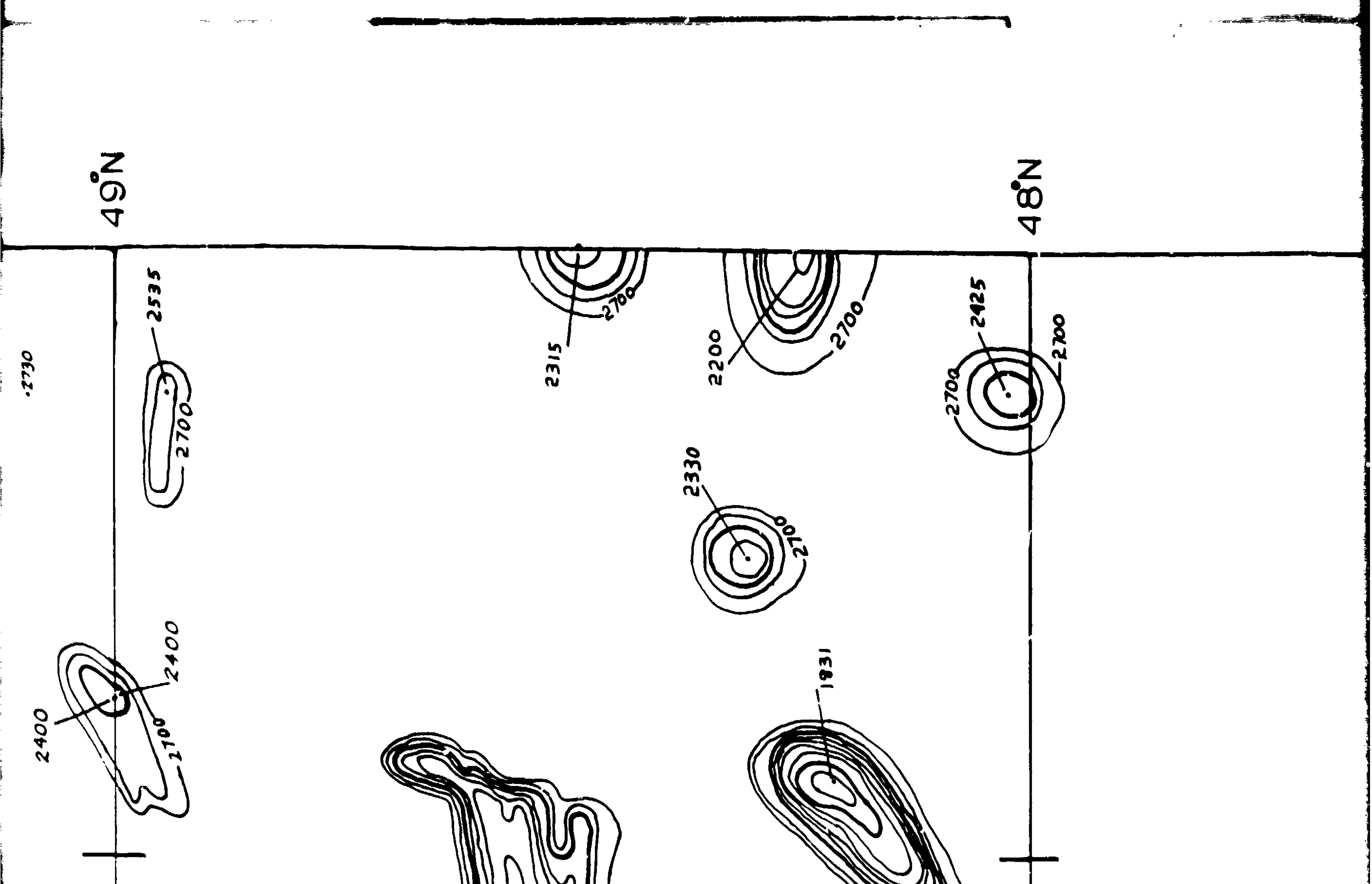
B-84

B-83

4


50°N
49°N
2525
2640
2630
2650
2600
2100
2060
2320
2250
2473
2380
2700
2730
2535
2400
2085

5


49°N
48°N
2730
2535
2700
2315
2200
2425
2330
2400
1931
2070
2000
1990
2630
2245
2355
2100

6

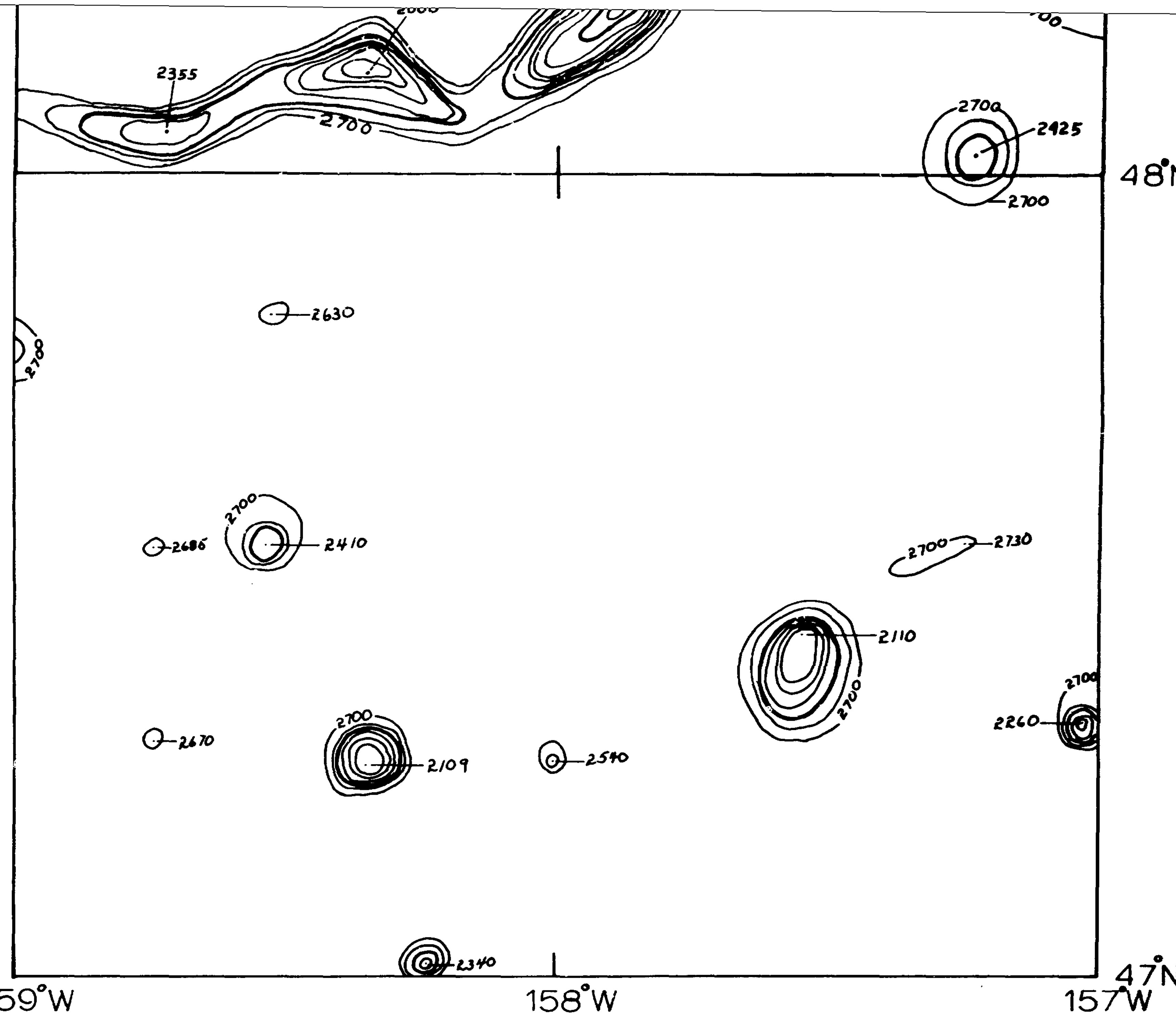


CHART 4

Figs. B-80 - B-89 – Two degree bathymetric strip chart (U)

d. PARKA I Track Charts of Bathymetric Survey Ships

——————— USC&GS – ESSA "SEAMAP" Survey Tracks

- - - - - - - - - R/V ROBERT D. CONRAD, 1968

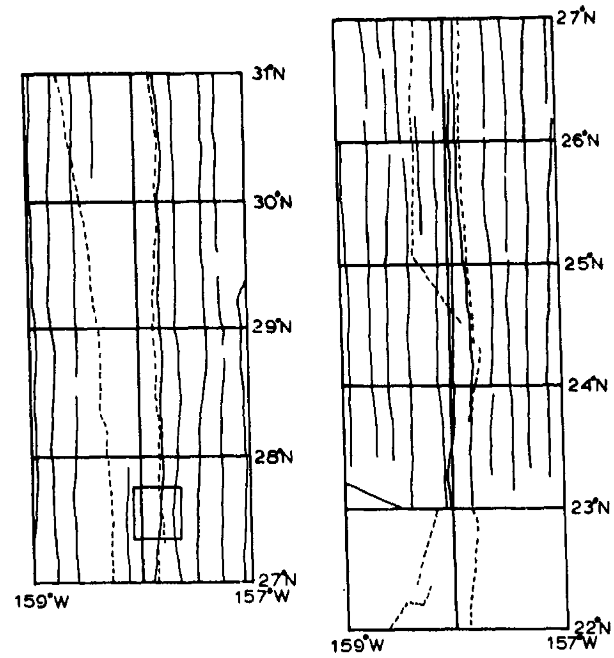


Fig. B-90 – Ship track chart of two degree bathymetry (U)

Note: Twenty-nm square shows area centered on FLIP site covered by a special survey by the USC&GSS McARTHUR in May 1968.

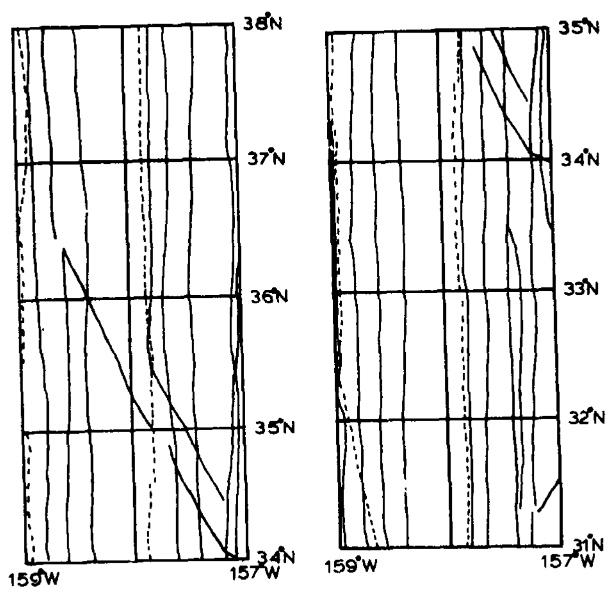


Fig. B-91 – Ship track chart of two degree bathymetry (U)

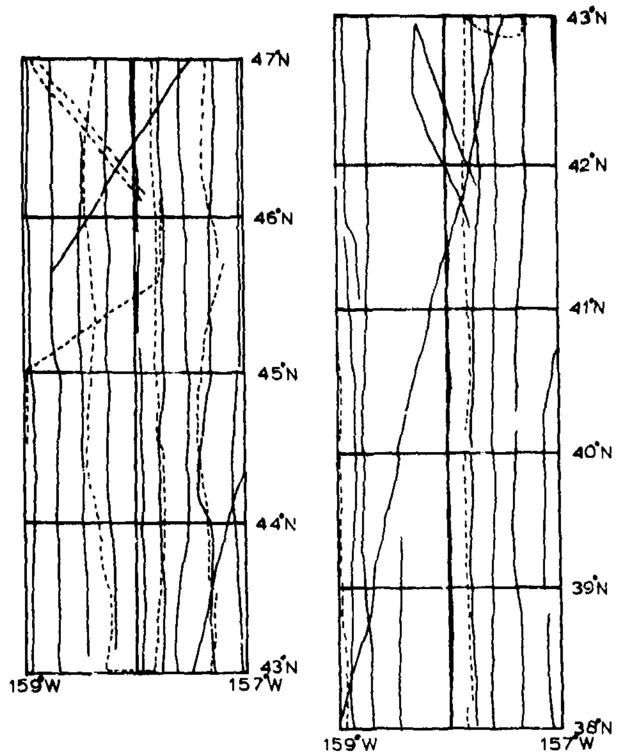


Fig. B-92 — Ship track chart of two degree bathymetry (U)

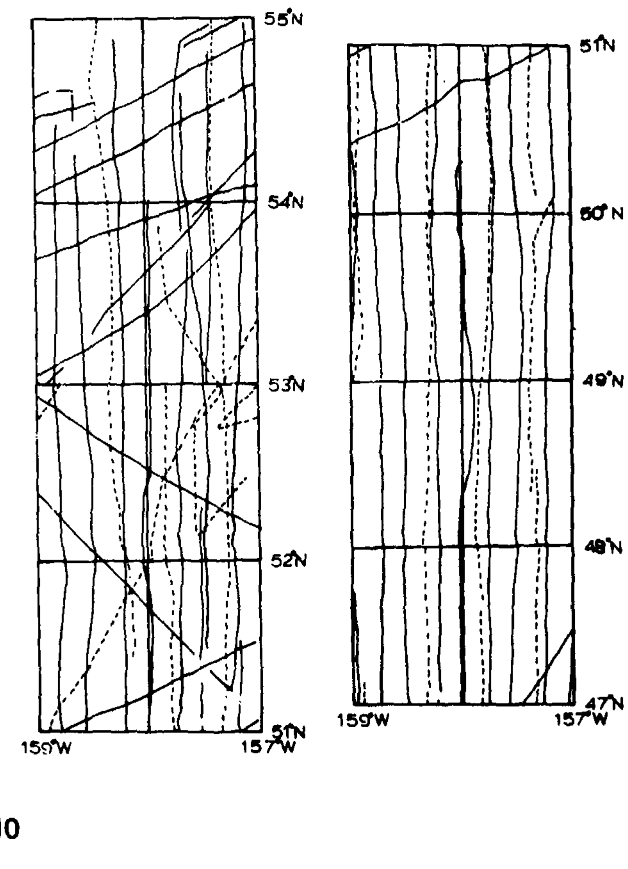


Fig. B-93 — Ship track chart of two degree bathymetry (U)

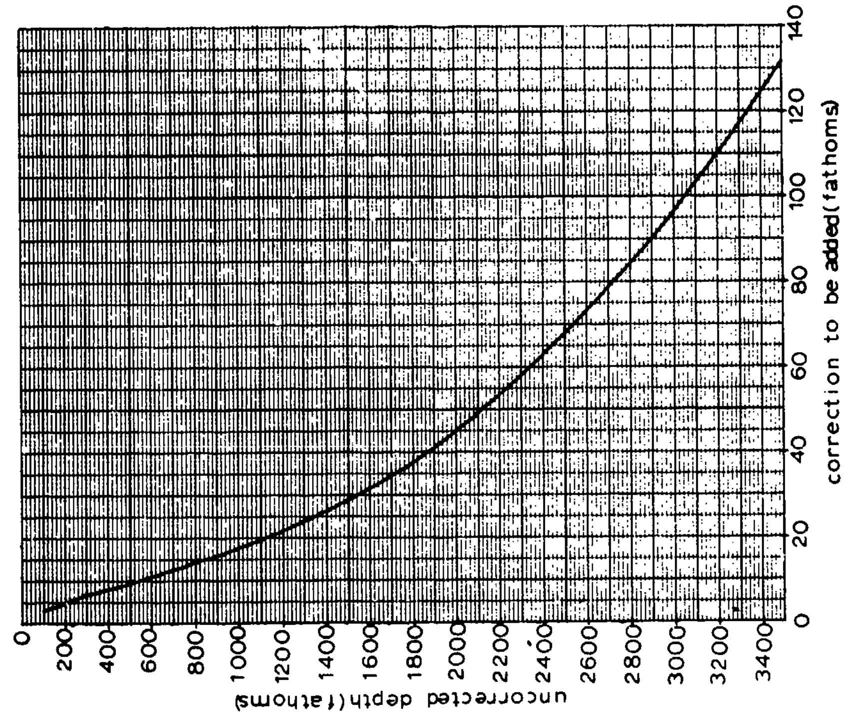


Fig. B-94 – Depth correction nomogram for 22° to 36°30′ N. Latitude along 158° W. Longitude (based on Matthews' Tables, Area 42) (U)

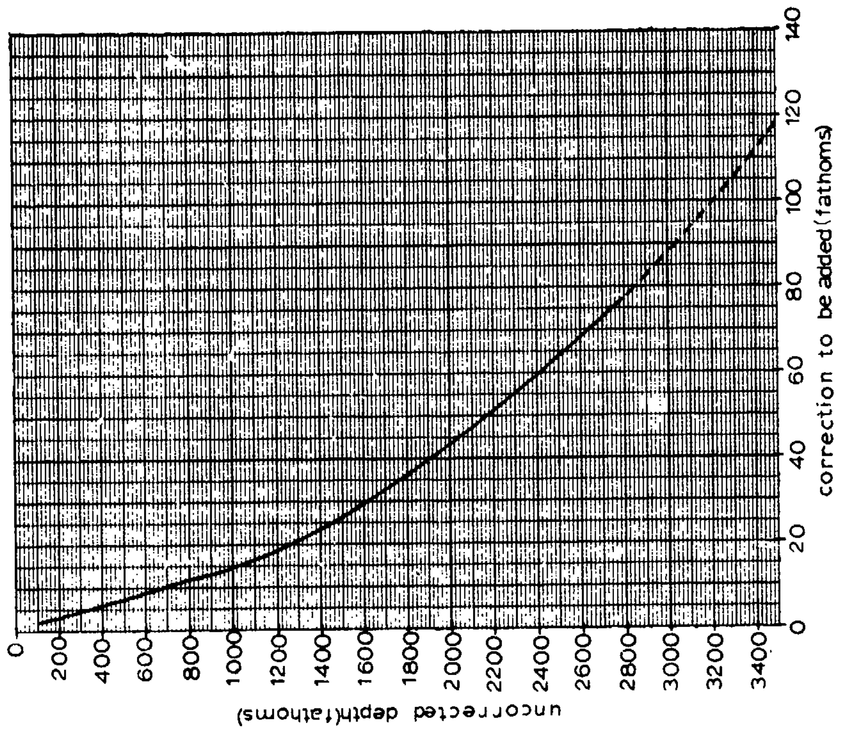


Fig. B-95 – Depth correction nomogram for 36°30′ N. to 41°00N. Latitude along 158° W. Longitude (based on Matthews' Tables, Area 43) (U)

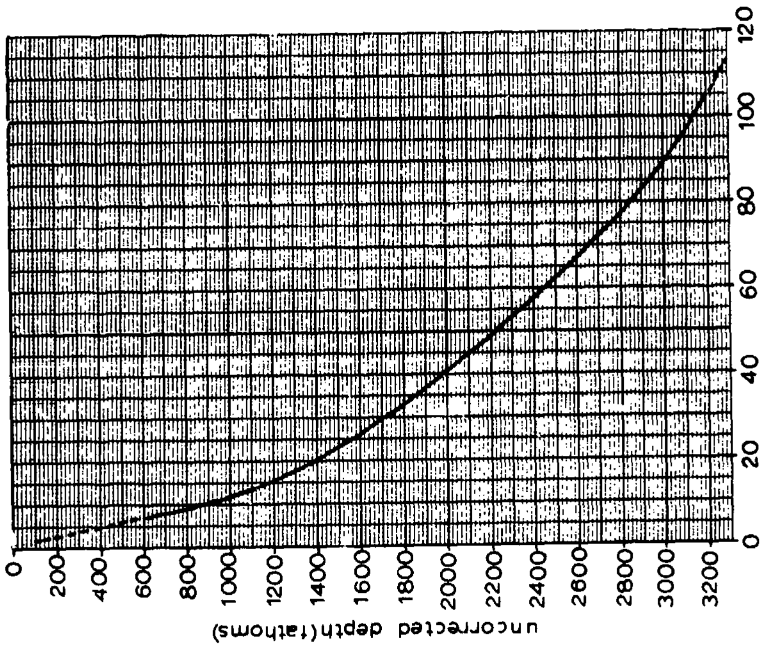


Fig. B-96 – Depth correction nomogram for 41° to 50°30′ N. Latitude along 158° W. Longitude (based on Matthews' Tables, Area 44) (U)

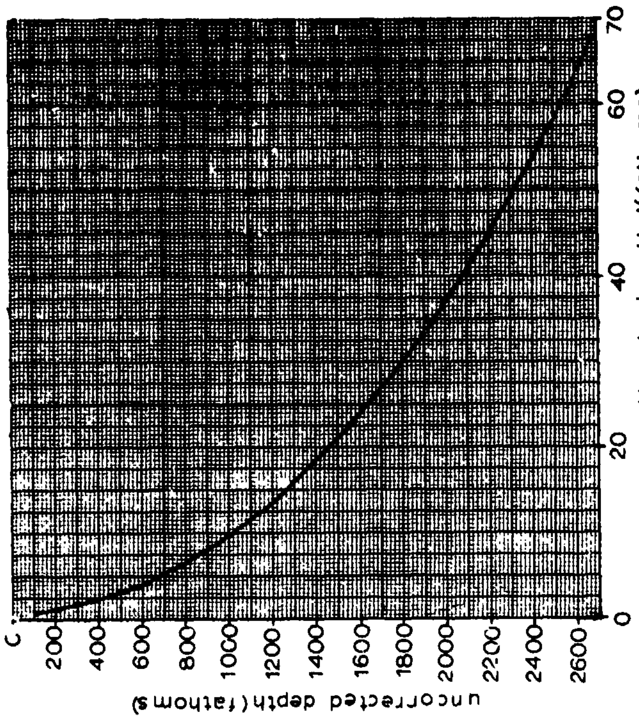


Fig. B-97 – Depth correction nomogram for 50°30′ to 52° N. Latitude along 158° W. Longitude (based on Matthews' Tables, Area 24) (U)

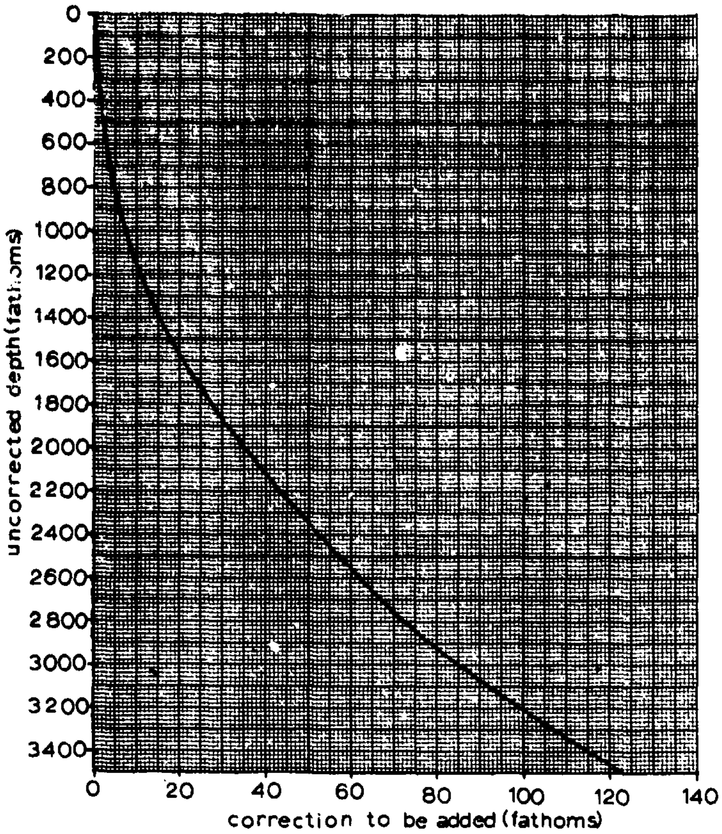


Fig. B-98 – Depth correction nomogram for 52° to 55° N. Latitude along 158° W. Longitude (based on Matthews' Tables, Area 45) (U)

14. Geology and Geophysics

J. I. Ewing
Lamont-Doherty Geological Observatory

a. General

The area between the Hawaiian chain and the Aleutian continental shelf is one of diverse topography and structure. Several major physiographic regions can be identified. The line of Hawaiian shield volcanoes with its associated moat and outer arch characterizes the region south of 25°26'N. Farther north is an area of seamounts and abyssal hills crossed by a series of major east-west trending transcurrent or 'transform' faults of which the Murray, Mendocino, and the more recently described Surveyor are the most important. These fracture zones delineate areas of the sea floor having different regional depths. North of 43°44'N lies the Aleutian plain, one of three large interconnecting abyssal plains in the Gulf of Alaska. It is in this area where the sea floor is most level and smoothest, although it is not flat and undisturbed everywhere since minor changes in depth of up to 300 meters occur, due to faulting, folding and erosion in the underlying sediments, and seamounts over a kilometer high are by no means infrequent. The Aleutian plain slopes gradually upward toward the north until it is terminated by the southern edge of the Aleutian trench, the fourth major physiographic feature, which is a deep tectonically active arcuate trough, reaching depths of 5.5–6.5 kilometers, running parallel to and approximately 200 kilometers south of the Aleutian Islands.

b. Sedimentary Provinces

Each of the physiographic regions in Figure B-99 is underlain by its own distinctive sequence of sediments. It may be expected, therefore, that each area is characterized by its own acoustically distinct bottom. For the reasons given below much of the Aleutian trench can be considered similar in the acoustical properties of its sediments to the Aleutian plain. We therefore divide the sediments into three types which can easily be distinguished on the 3.5 kHz sounder records and on recordings made by the airgun profiler using frequencies in the range 20-300 Hz.

(1) Type A. Well-stratified sediments containing many nearly horizontal reflectors rest unconformably upon an uneven strong reflector that the sonobuoy data indicate is the top of a high-velocity (4.5-6.0 km/sec) 'basement' volcanic layer (Figure B-100). In some parts there is evidence for layered sediments covering the basement, which are so highly reflective that basement arrivals are not observed. Stratification is also shown on the 3.5 kHz recordings, but the penetration is generally not sufficient to reveal basement except where it is covered by only a few tens of meters of sediment. The total thickness of the stratified material is variable, but is generally more than 100 meters and less than 2 kilometers. The great thicknesses are found in the Aleutian trench and the northern part of the Aleutian plain.

Structural relations suggest that the layer of type A sediments has been built up largely of coarse turbidites interbedded with finer grained sediments. The top few tens of meters are probably composed entirely of pelagic material (see below).

(2) Type B. Acoustically 'transparent' sediment of pelagic origin, containing no strong reflectors, overlies a rough basement surface or a more even surface giving more coherent arrivals, which is interpreted as the top of a sequence of well-compacted or closely stratified sediments lying just above the true basement (Figure B-101). The sediments below the transparent material form an opaque layer that in some areas is separated from basement by a deeper transparent zone. The 3.5 kHz recordings usually show the junction between the opaque material and the overlying transparent sediments which takes on some of the appearance of typical basement because of its high reflectivity, its small-scale roughness and associated side reflection hyperbolae (Fig. B-101), but a comparison of the arrival time of the reflector on the 3.5 kHz sounder in Figure B-101 with the corresponding portion of the profiler record will clearly indicate that the strong arrivals on the former come from the transparent/opaque sediment contact and not the basement. A core taken in the southern part of the seamount-abyssal hills province indicates that ash layers may be responsible for the strong reflections.

In contrast to the sediments of type A, those of type B are very thin, usually 50 meters or less. In areas between the fracture zones where the relief is not too great the transparent sediment forms a remarkably thin and uniform cover over the basement. In the immediate vicinity of the fracture zones sediment appears to be absent locally.

(3) Type C. Sediments exhibiting a well-defined stratification consist of many closely spaced strong reflectors (Fig. B-102). The reflectivity of the internal layers is high and penetration is limited, so the basement surface is generally difficult to identify in the profiler records. Data taken with sonobuoys as receivers indicate high-velocity (3.5-5.0 km/sec) material close to the surface which suggests that lavas may make up an appreciable portion of type C material. The contribution of volcanic ash to the total accumulation is probably minor since the activity of the Hawaiian volcanoes has been generally confined to quiet effusive phases rather than to explosive volcanism.

The distribution of these types of sediments is shown in Figure B-99 and can be seen to be exactly correlated with the physiographic regions identified earlier. A cross section showing sediment thickness along the PARKA I track is shown in Figure B-103.

c. Geological Considerations

The source of the sediments of the Aleutian plain and the Hawaiian arch is of some interest since there appears to be no method by which thick stratified sediment, probably largely deposited from turbidity currents, could accumulate in these areas at the present time. The Aleutian abyssal plain is now isolated from the Alaskan shelf and interior by the intervening trench. There is no obvious route for sediment transport from the Alaskan abyssal plain to the east. The Tufts abyssal plain is joined to the southern part of the Aleutian plain but, because of the southerly dipping regional slope of the latter, there appears to be no means, at present, by which most of the thick Aleutian turbidites could be deposited. Similarly, the stratified material on the Hawaiian arch appears to thicken toward the Hawaiian ridge but it is now cut off from this feature by the intervening moat which is some 200-500 meters deep.

It seems, therefore, that in the case of the Aleutian abyssal plain most of the sediments were laid down before the trench became deep enough to isolate the principal source of sedi-

ment. The thickening of the turbidites toward the trench and the regional slope of the plain to the south are strong reasons for supposing that this was so. The turbidites can even be followed well into the trench as far as the foot of the north wall where they are most thickly developed. In places on the trench axis the succession is overlain unconformably by more recent turbidites probably derived from the northeast.

It has been suggested that the turbidites of the Aleutian plain are now covered with several tens of meters of pelagic sediments which were deposited after the Aleutian trench was formed. Several lines of correlated echoes can be distinguished within the top 100 meters on the profiler records and many reflectors are clearly discernible within the top 50 meters on the 3.5 kHz sounder (Fig. B-100). Ten meter cores from the Aleutian plain show that the shallow reflectors are layers of volcanic ash interbedded with pelagic red clay. Evidently each reflection on the 3.5 kHz chart comes from an ash layer whereas most of the reflectors on the profiler record are the deeper lying turbidites.

Much of the stratified material on the Hawaiian arch may also have predated the formation of the intervening moat although the data could also be consistent with a source of supply on the arch itself if a large part of the stratified material is composed of lava. The lavas could have been extruded and become interbedded with sediment during the isostatic sinking of the Hawaiian ridge during Tertiary time and the tensional conditions that must have prevailed during the formation of the arch.

d. Summary

In the foregoing discussion we have considered the entire sedimentary section as belonging to type A, B or C. In reality there is a layer of acoustically transparent sediment over the entire area, but its thickness is quite variable. In the B area (Fig. B-99) a transparent layer, that contains only one internal reflector, constitutes almost half of the entire section. In area C there is only a very thin layer of this type. Two cores taken in the latter area during PARKA I hit manganese crust sufficiently hard to damage the cutting edge severely after only a few meters penetration. In area A there is almost certainly a pelagic layer several tens of meters thick consisting mainly of clayey material typical of that in area B. However, the numerous ash falls in area A have made the pelagic layer acoustically quite similar to the underlying turbidite section.

For high-frequency sound, we would expect that both areas A and C would be highly reflective. On the other hand, area C should be more reflective for low-frequency sound and probably will produce less smearing of arrivals due to multipaths resulting from reflection at greatly varying depths. Sonobuoy profiles in area C show high-velocity material (approximately 4 km/sec) lying only a few tens of meters below the sea floor. Comparable velocities in areas A and B are found only at the base of the sedimentary section.

Area B is probably characterized by low reflectivity, both for high and low frequencies, primarily due to bottom (and sub-bottom) roughness. Substantial portions of area B, particularly those between 26° and 30°N and between 36° and 42°N are characterized by both regional and local roughness and undoubtedly constitute the poorest and most complicated reflecting surfaces of any along the track. This extreme roughness is associated with fracture zones and may be expected to be encountered at approximately the same latitudes along neighboring meridians.

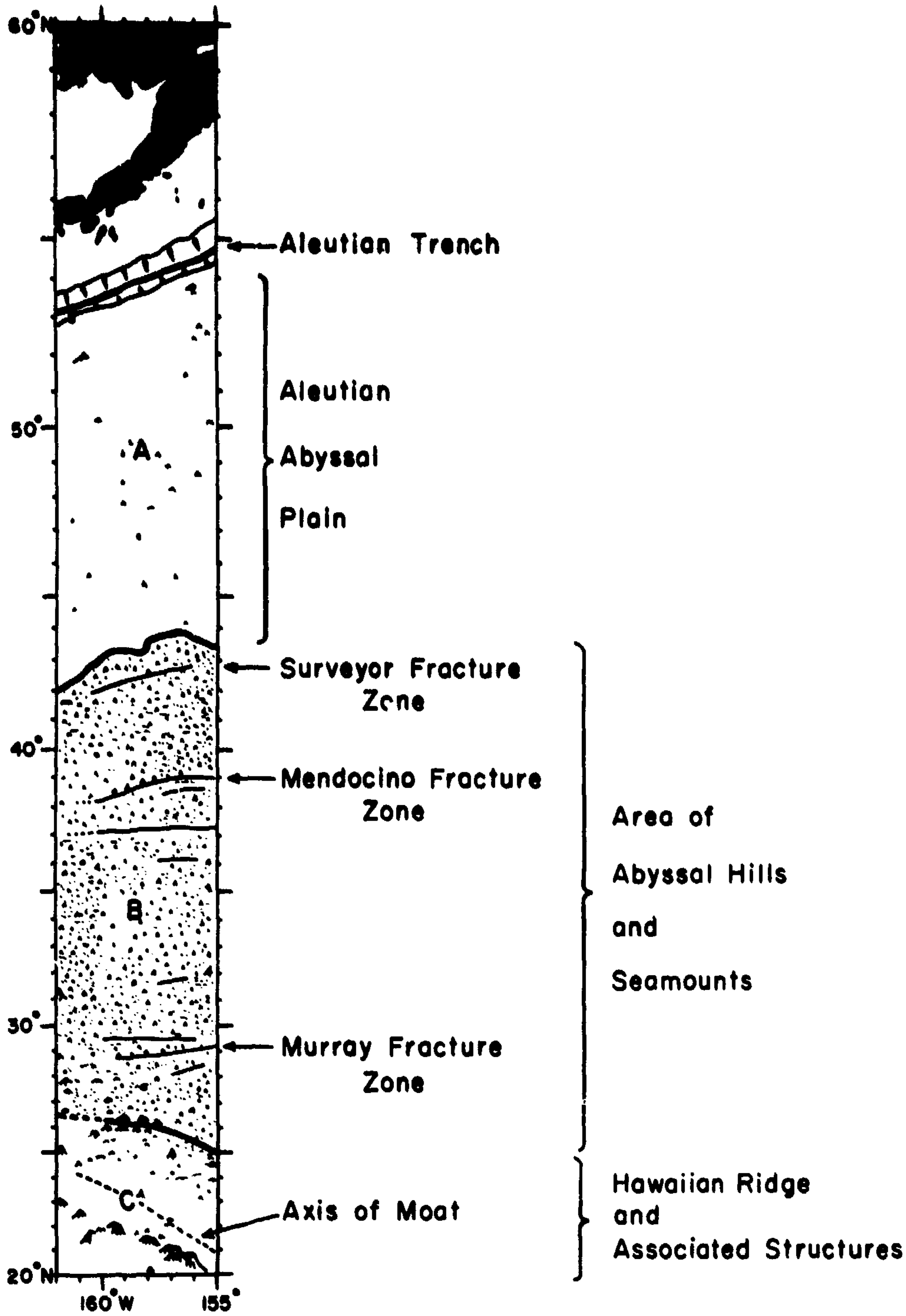


Fig. B-99 – Sketch map of region between Hawaii and Alaska indicating bottom relief and areal extent of sediments of type A, B and C discussed in the text (U)

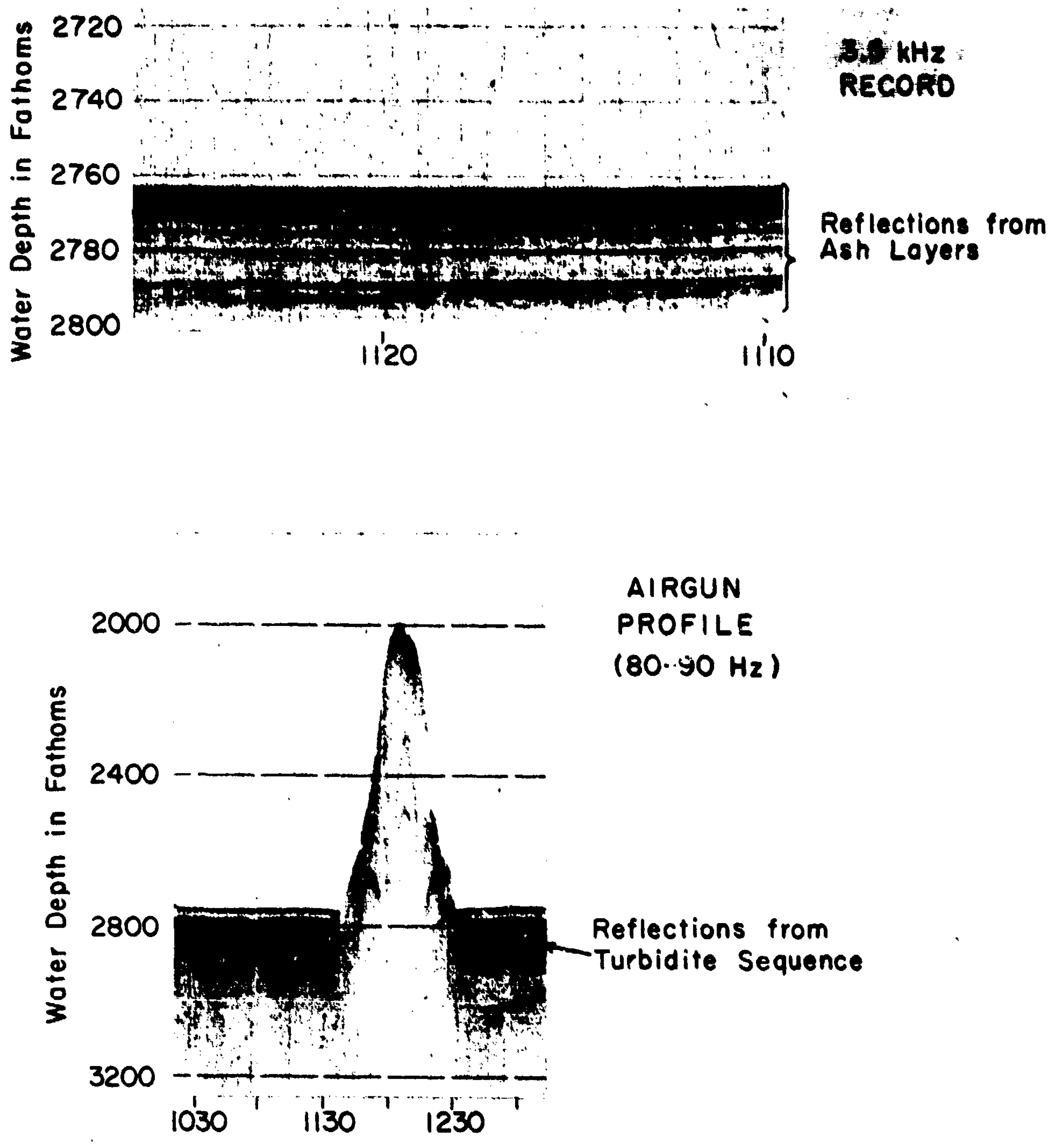


Fig. B-100 – Type A sediments. Horizontal scales are time of day; recordings made at 10 knots; 31 August (U)

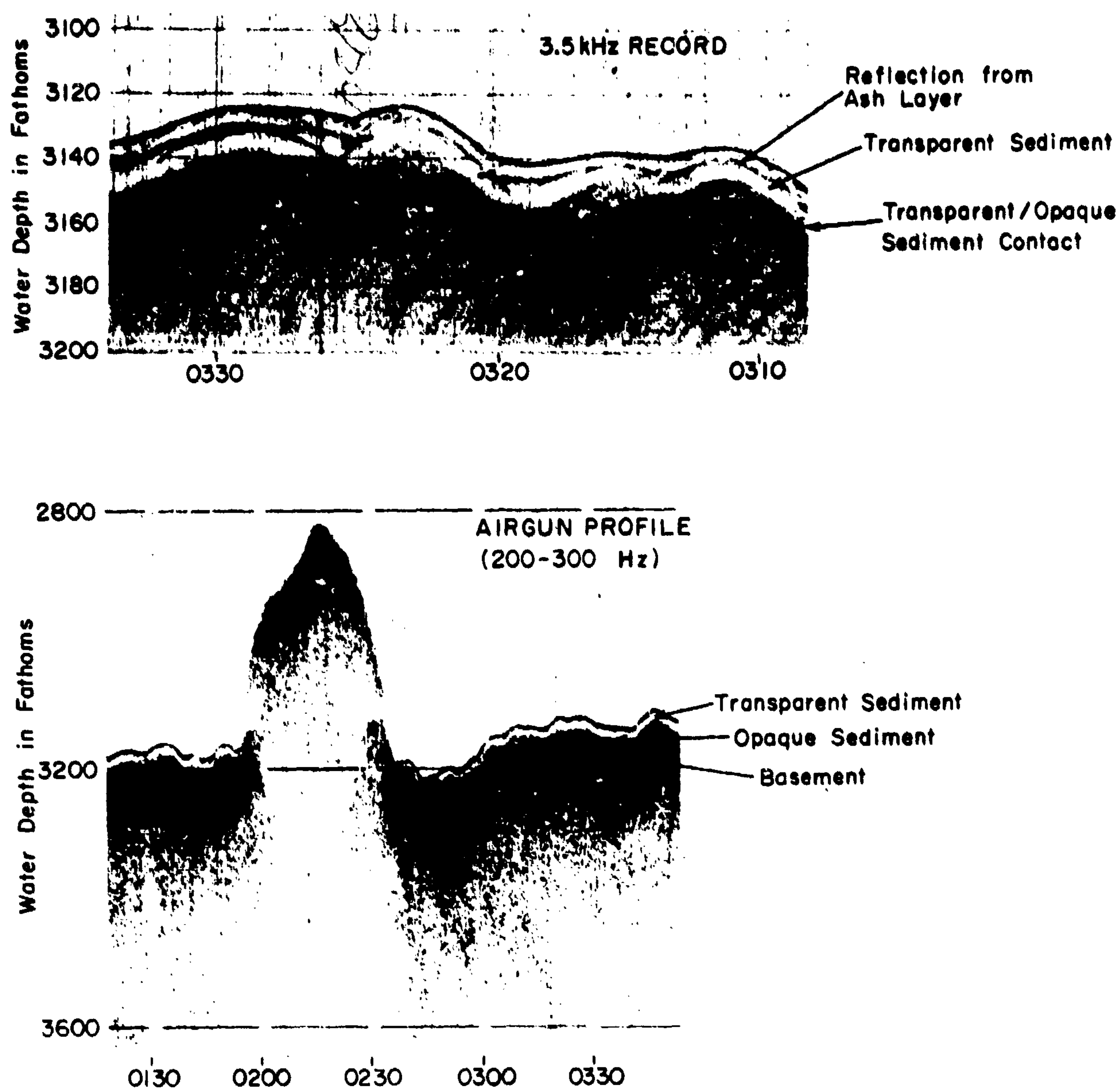
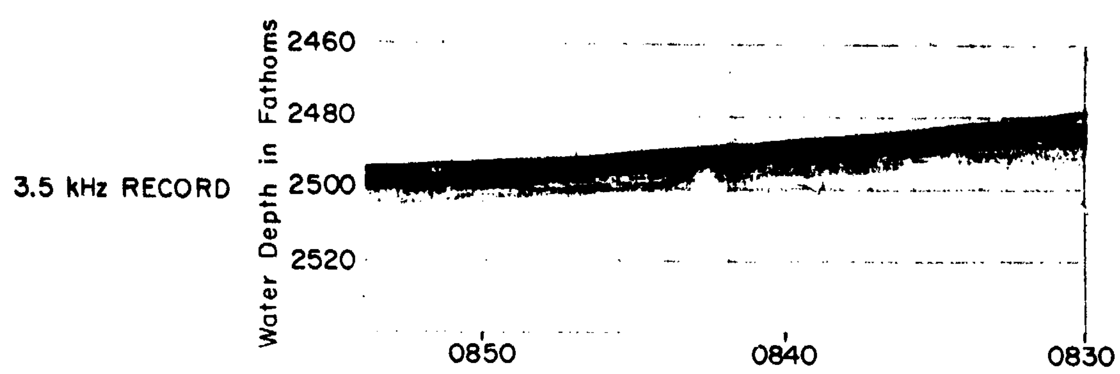


Fig. B-101 – Type B sediments. Horizontal scales are time of day; recordings made at 10 knots; 20 September (U)



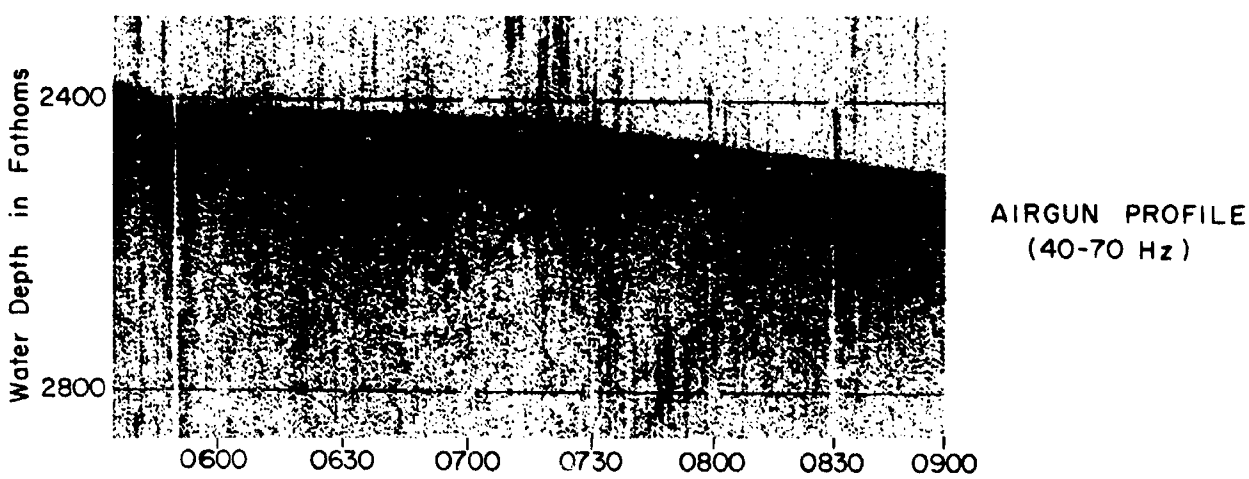


Fig. B-102 — Type C sediments. Horizontal scales are time of day; recordings made at 10 knots; 24 September (U)

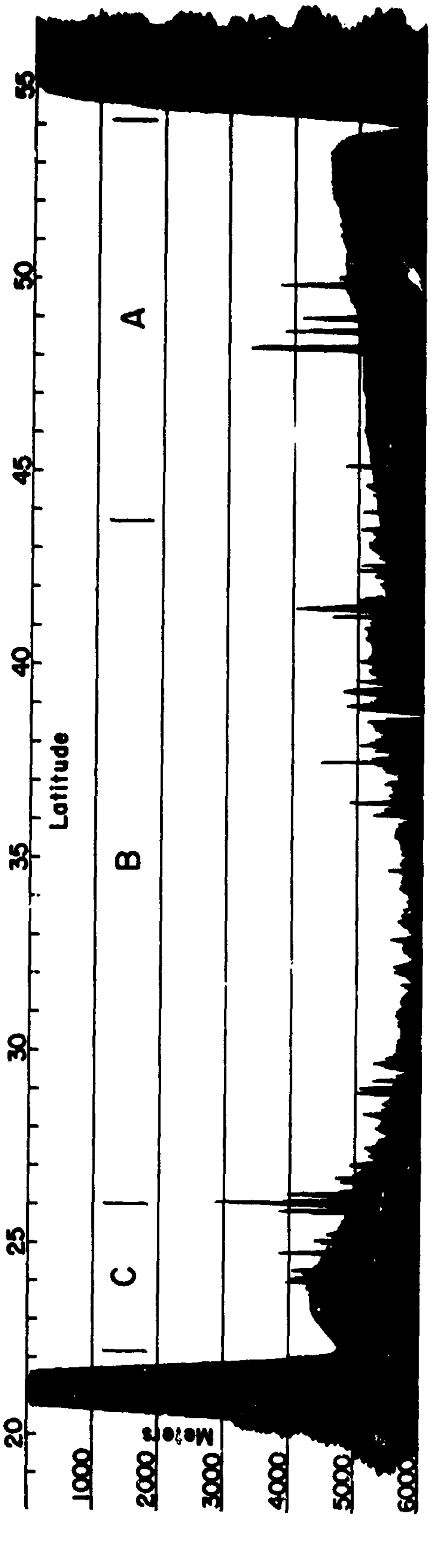


Fig. B-103 – Sediment distribution along PARKA I track. Thickness of sediment (stippled) is based on sound speed of 2 km/sec. Except in the immediate vicinity of fracture zones and on large peaks, there is an approximately uniform cover slightly less than 100 meters thick in area B. See Figures B-100, B-101, and B-102 echograms typical of areas A, B, and C. (U)

Appendix C (C)

EVENT LOG ON USNS SANDS

R. W. Hasse
Navy Underwater Sound Laboratory

2 August – Friday

SANDS arrived Hawaii 1 August at 2100W having departed New London 1 July. Moored Iroquois Point, Berth Whiskey-3 to unload charges destined for CONRAD and RADFORD. Departed 1300W for Berth Hotel-3 for refueling. Upon completion refueling transferred to Berth Mike-4 for reprovisioning. Reprovisioning could not start until Monday so SANDS proceeded to Honolulu Piers 28-29 to prepare to check out equipment with FLIP scheduled to arrive Saturday at 1800W.

4 August – Sunday

SANDS arrived Pier 28 at 1100W and moored outboard PACIFIC APOLLO. Grooming of scientific instrumentation necessary for the data link between SANDS and PACIFIC APOLLO started.

5 August – Monday

Received copies of FNWC propagation predictions. Operation Plan for exercise received from ASWFORPAC. Grooming of equipment continues. Detailed testing of computer program against test inputs underway.

6 August – Tuesday

Continued checking out equipment and aligning instrumentation for the PARKA I Experiment.

7 August – Wednesday

Developed projected movement plan as follows:

SANDS – depart Pier 28 Friday 9 August 0800W
arrive position ALFA 10 August 2000W

PACIFIC APOLLO – depart Pier 28 Friday 9 August 1800W
arrive position ALFA 12 August 0400W

Distance to position ALFA from Pier 28 approximately 403 nm. SANDS nominal SOA 11 knots. PACIFIC APOLLO with FLIP in tow nominally 7 knots.

8 August – Thursday

Presail conference at University of Hawaii 0900W Geophysics Building. Afternoon spent making preparations for getting underway.

9 August – Friday

Underway 0830W. Continued check-out of computer programs.

10 August – Saturday

Underway position ALFA (27°30'N, 157°50'W). Continuing check-out and cali-

bration of system. Arrived position ALFA 1940W. Began lowering 300-lb Danforth deep sea anchor. Initial lowering speed 17 meters/min to allow sufficient weight overboard to take up slack. Increased speed to 61 meters/min at 2130W.

Wind 090°T/8 knots. Swell 140°T/2 ft.

11 August – Sunday

Deep anchored on station. Water depth 5435 meters. Anchor cable out 8344 meters. Initial set in 11 hr was 13 nm at 136°T. Bearing from ALFA 090°T approximately 2 nm. Wind light, anchor tension was measured to be 7000 lb; however, there is some question concerning the proper operation of the tensiometer. 1230W Velocimeter lowered. 1942W Gas turbine on line. 2230W Velocimeter aboard.

Wind 070°T/6 knots. Sea smooth. Swell 130°T/3 ft.

12 August – Monday

Deep anchored on station. PACIFIC APOLLO and FLIP sighted 0030W bearing 202°T, 9.8 nm. FLIP lying off awaiting daybreak. First light about 0530W. FLIP flipped. PACIFIC APOLLO passed SANDS tether line to FLIP. 0915W Secured with 10,000 ft out. FLIP measures 1.6 nm from SANDS on radar. 1540W SANDS lowered hydrophones to 3000 ft.

Wind 060°-090°T/5-10 knots. Waves 070°T/1-2 ft. Swell 130°T/3-5 ft.

13 August – Tuesday

Tethered to FLIP as before. Anchor dragging. Southerly drift measured at about 0.3 knots. Charts indicate shallower water about 70 nm south that could cause difficulties with FLIP's deepest hydrophone. At 1800W began veering additional anchor cable. 2015W finished veering anchor cable. 12183 meters out.

Wind 060°-100°T/6-8 knots. Waves 060°-090°T/1 ft. Swell 140°T/3-5 ft.

14 August – Wednesday

Tethered to FLIP as before. 0807W Bow thruster at 250 rpm in attempt to reduce drift rate. 0850W Retrieving hydrophone cable. Wire had parted about 2300 ft from bitter end. 1015-1745W Velocimeter cast to 5182 meters.

Wind 040°-090°T/6-12 knots. Waves 040°-090°T/3 ft. Swell 120°T/3-5 ft.

15 August – Thursday

Anchored as before. Bow thruster at 250 rpm. 1000W FLIP sending signals over the rf telemetry link. Using Hydrophones 1, 3, 5, 7, and 8. Following a series of test shots and pulses from CONRAD's large air gun, COMEX Phase 1 at 1745W with Event FANTAN I ALFA, i.e., 3-lb TNT charges only, alternating 60- and 500-ft depths.

Wind 060°-090°T/10-15 knots. Waves 060°-090°T/2-3 ft. Swell 120°T/4 ft.

16 August – Friday

Continuing Phase 1 measurements. 1447-2020W Velocimeter cast to 3240 meters. 1800W Secured from Event FANTAN I ALFA at a range of 65 nm from Point ALFA and pre-

pared for continuation using large air gun. Commenced 2230W.

Wind 095°T/10-18 knots. Waves 095°T/3-5 ft. Swell 095°T/3-6 ft.

17 August – Saturday

Anchored as before with bow thruster at 250 rpm. 0515W Transferred one bag of outgoing mail and one box of floats for RADFORD to TERITU, Unable to complete transfer of remaining material because of sea conditions. 0750W Returned to explosive sources after air gun failed at range of 52 nm north of ALFA. 1430-2330W Velocimeter cast to 4800 meters.

Wind 090°T/12-16 knots. Waves 090°T/3-5 ft. Swell 120°T/4-6 ft.

18 August – Sunday

At anchor with FLIP 1.7 nm astern. Using gas turbine and bow thruster at 250 rpm to reduce set. 1510-2100W Velocimeter cast to 4597 meters.

Wind 110°T/10-16 knots. Waves 095°T/4 ft. Swell 120°T/5 ft.

19 August – Monday

Beginning with shot 1460 at approximately 956 kyd, the integration time was changed from 15 to 7.5 sec and the sampling rate doubled so as to improve S/N ratios. Gain into the computer was increased 10 db. 0300W Deep anchor cable was observed to be parting near the bull nose. Increased turns on bow thruster to 350 rpm. 0310-0405W Heaving in on cable until cable out reads 12073 meters. Bow thruster reduced to 250 rpm. 0730W Telemetry transmitter failed on FLIP. 0815W Frayed section of stopper on tether line cut out. Stopper repositioned and chafing gear increased. 0900W Telemetry back on line using spare transmitter. 1405-2010W Velocimeter cast to 4726 meters. Had discussion with FLIP concerning calibration differences observed on H-1 mounted on bottom of FLIP. This hydrophone is on circuit that is different from the other seven hydrophones and a 15-db attenuation in the circuit caused problems in calibration interpretation. 2014W Tether line to FLIP parted. Secured bow thruster and commenced heaving in on deep sea cable. Just a few minutes after the tether line parted the rf telemetry transmitter on FLIP failed. Estimated time to raise anchor – 10 hr. Requested CONRAD to cease SOA and the dropping of charges. FLIP indicated that both rf telemetry transmitters are now inoperative and not repairable aboard. Made measurements on velocimeter cable. Attenuation at 170 kHz is 48 db. Estimate that if FLIP can drive cable with 1 V signal reception should equal that previously experienced. Weighed short length of cable. Calculated weight – 75 lb/1000 ft, 56 lb/1000 ft in water. Requested FLIP to consider taking velocimeter cable aboard so that operations could continue using hardwire link. FLIP concurred. Asked FLIP to consider sonobuoys as replacement for rf telemetry transmitter. FLIP indicated that it could probably rig such an arrangement. Requested personnel at OCC Kaneohe to obtain and air drop four sonobuoys and one receiver tomorrow.

Wind 090°-100°T/12-18 knots. Waves 090°-110°T/4-5 ft. Swell 110°-120°T/5-6 ft.

20 August – Tuesday

0124W Requested PACIFIC APOLLO to close range on FLIP/SANDS in case assistance

required in retethering and passing hardwire. Also requested CONRAD to backtrack approximately 100 nm so as to cover portions of track missed. 0618W Anchor cable aboard. Wire parted, anchor lost. 0637-1026W Restored 2800-meter tether line to FLIP, also 4000-meter hardwire telemetry link. Received airdrop of sonobuoys. Released PACIFIC APOLLO from recall at 1000W to resume operations. Deep sea anchor reset 1443-1630W. Calibrations with hardwire link. Resumed normal operations again at 1530W using hardwire link. FLIP is now tethered 1.3 nm from SANDS. Anchor cable out is 9955 meters. At 1535W H-1 was replaced by H-3.

Wind 060°-130°T/8-18 knots. Waves 070°-130°T/4-5 ft. Swell 130°T/5 ft. Depth 2900 fm.

21 August – Wednesday

TERITU came alongside at 0900W with mail. Rubber boat transfer. 1215W FLIP replaced H-1 with new H-1. 1730W Power failure on FLIP. 2212W Bow thruster with gas turbine at 300 rpm. 2255W Reduced to 200 rpm.

Wind 090°T/14-16 knots. Waves 090°T/4 ft. Swell 120°T/5 ft.

22 August – Thursday

0001-0400W Heavy strain on tether line. 0700W Secured bow thruster and commenced heaving in anchor. Wire unlayed and strands broken. Jettisoned outboard 4000 meters. Anchor lost. 1055W Started heaving in tether line. 1200W Discussed with FLIP the possibility of redefining point ALFA farther north and to the east because of past drift experience this experiment. 1500W Secured heaving in tether line with 2583 meters out. 1600W Gas turbine on line. Ship rolling moderately in rough sea and swell. 2200W Three or four very large acoustic signals received in vicinity of shots 3050-3066. Motor breakdown on Monroe occurred causing it to be off line about 1 hr. Just prior to shot 3102 removed 400-Hz input to computer and replaced it with 63 Hz and 200 Hz. Around shot 3144, H-7 on FLIP quieted down for no apparent reason.

Wind 090°T/16-25 knots. Waves 090°T/4-5 ft. Swell 090°T/6-7 ft.

23 August – Friday

Vessel lying with stern to sea and swell. At shot 3425 FLIP switched from new H-1 to old H-1. The cable on new H-1 had parted. At shot 3452 FLIP reinstalled new H-1. In vicinity of shots 3416 and 3418 large acoustic signals being received from strangers. 1700W Went through extended period with no radio communications because of QRM and channel shifting. Beginning with shot 3630 interchanged channels into computer so that aperture control signals would come from 100-Hz vice 31-Hz signals.

Wind 080°-090°T/15-20 knots. Waves 070°-090°T/4-6 ft. Swell 090°T/6-7 ft.

24 August – Saturday

Spikes appearing on H-5 with about 100-Hz repetition rate. Possible whales. (A few days later FLIP personnel reported having seen whale for an extended period about FLIP.) Another large acoustic stranger around shot 3966. 1600W Noted that when FLIP

talked on Channel 5 the signal is picked up on H-1. CONRAD revised ETA position CHARLIE is 25 August, 1000Z. Terminated Phase 1A at 2400W.

Wind 070°-090°T/15-24 knots. Waves 060°-090°T/5-6 ft. Swell 060°-090°T/6 ft.

25 August – Sunday

0140W Commenced heaving in telemetry cable. Cut cable at 710 meters. 0550W FLIP released tether line. SANDS heaving in. 0600W MARYSVILLE alongside with replacement 300-lb Danforth anchor and mail. 0716W Underway to restation. Starting point for Phase 2 established 39 nm bearing 041°T from ALFA. FLIP expects to arrive on station 0630W tomorrow, vertical by 0730W, and tethered by 0800W.

Wind 070°-090°T/10-15 knots. Waves 060°-090°T/3-4 ft. Swell 090°T/5 ft.

26 August – Monday

PACIFIC APOLLO speed with FLIP has bee duced to about 3 knots. Because of slow ed will establish station at 20 nm bearing 04 T from ALFA. SANDS underway to rendezvous with FLIP. Check-out of computer program or Phase 2 being accomplished. 0900W SANDS approaching FLIP and PACIFIC OLLO on station. 1125W Double tether line and hardwire link established with FLIP at 0.5 nm. 1130W Began calibrating. 1217W Gas turbine and bow thruster at 250 rpm/245° bow thruster and angle. 1437W Bow thruster stopped. 1505W Gas turbine secured. 1525-1930W Anchor cable out to 5972 meters. Initial drift before cable was in water in excess of 1 knot. Status of deep anchor cable: three strands broken at 12183 meters, meters have been discarded, thus only 7083 meters available. 2100W Water depth 5530 meters. 1745W Increased speed on bow thruster to 400 rpm. 2150W FLIP array at last hydrophone calibration. Calibration complete at 2155W. RADFORD estimates 33 hr to get to ALFA after COMEX. 2345W FLIP array at depth and ready for receiving signals. Requests RADFORD to send signals with unit at 60 ft. FLIP loses power for 5 min. 2350W FLIP reports tilt of array is in excess of 5°. FLIP reports noisy H-7. Switching SANDS to H-6. Same calibration is assumed to hold.

Wind 070°-090°T/8-14 knots. Waves 070°-090°T/2-3 ft. Swell 090°T/3-4 ft.

27 August – Tuesday

Moored as before. 0045W RADFORD indicates junction box on transducer flooded. Unit must be brought aboard and repairs effected. 0150W Gas turbine and bow thruster at 250 rpm/180°. 2000 meters of telemetry wire being employed. 0630W RADFORD again ready to start tests. 0700W RADFORD reports drawing too much current on transducer. Necessary to bring transducer aboard for further investigation. 0834-0930W Increased deep sea anchor cable out to 7289 meters. 1150W RADFORD reports source in water and operable at 60 ft. 1220W Requested RADFORD to lower source to 500 ft. 1649W Switched from hydrophone H-3 to H-2. 1745W Increased bow thruster speed to 400 rpm. 1800W Requested ship to try main engines in attempt to reduce drift which is about 0.7 knot. When bow thruster is increased to 400 rpm FLIP reports feeling the pull. 1823W One engine on line with slow ahead at 45 rpm.

Wind 090°T/8-15 knots. Waves 090°T/3 ft. Swell 090°T/4 ft.

28 August – Wednesday

Continuing bow thruster at 400 rpm, main engine at 45 rpm. 0309W Reduced bow thruster to 250 rpm. 0742W Secured bow thruster, half ahead on main at 70 rpm. 1230W Chart indicated ship can drift about 40 nm before getting into undesirable area. It will take RADFORD about 165 hr to make the required 1650 nm or about 6.9 days. FLIP/SANDS must drift less than 40 nm in the 165 hr or less than 0.25-knot average. Suggested to FLIP possibility of gaining positive ground while RADFORD is at close range in order to reduce propulsive power when RADFORD gets to the longer ranges. FLIP indicates less than 3-db increase in noise with SANDS engines going at this rate. Range to FLIP 0.5 nm. Signatures of shots at the minus ALFA position of RADFORD showing strong double peaks due no doubt to heavy reverberation and reflections from the very mountainous bottom terrain. 1730W Preparing to pass Omega and floats to RADFORD due about 2100W. Lowered lifeboat at 2020W to transfer Omega to RADFORD. 2150W Lifeboat developed engine trouble. 2158W RADFORD motor whale boat away with Omega and floats. RADFORD starts run again at 2330W.

Wind 090°T/8-15 knots. Waves 090°T/2 ft. Swell 090°T/4 ft.

29 August – Thursday

Continuing main propulsion with starboard engine at 70 rpm. 0800W RADFORD stopping to fuel. Back on line at 1500W. Checks made on computer program because CW program was not identifying hydrophone channels properly. Apparently they were in reverse order. They were corrected during this break period with RADFORD. 1700W Experiencing a westerly set which could put SANDS into undesirable areas. 1815W Increase speed on main engine to 80 rpm.

Wind 090°-110°T/8-12 knots. Waves 090°-110°T/2 ft. Swell 090°-130°T/4 ft.

30 August – Friday

Continuing with 80 rpm on main engine. 0300W Transducer aboard RADFORD ceases to operate. RADFORD indicated that transducer will be permanently out for remainder of exercise. Based on this information and the number of charges aboard RADFORD, have redefined experiment to go to ALFA plus 1300 nm using same shot sequence on a 15 min rather than an hourly basis. Shots 2 and 4 of the 5-shot sequence to be omitted since they are duplicative and reliability has been very good. This maximum range should take RADFORD past the transitional range of the SOFAR axis as observed during Phase 1. The density of shots possible also seems reasonable. 0315W Vessel commenced turn to right. 0319W Main propulsion all stopped. FLIP ahead 0.3 nm. 0347W Bow thruster on line 200 rpm/270°. 0353W Bow thruster stopped. 0415W No. 2 engine on main propulsion. 0425W Commenced heaving in anchor. 0512W Tether definitely determined to be parted. 0521W Hardwire telemetry line parted. 0642W Stopped heaving in on anchor cable. Bitter end aboard with approximately 1772 meters of cable and anchor lost. 0710W FLIP small boat brings FLIP end of tether line to SANDS. Checking of sonobuoy link for possible use as data link. 0730W OCC Kaneohe up on radio and informed of status. 0825W SANDS informed of airdrop scheduled for this morn-

ing. 0830W Airdrop of computer spare motor and power supply with mail. Drop lands about 10 nm from FLIP. Too far for FLIP small boat to retrieve. SANDS in process of pulling in tether line from FLIP so as to make them up with thimbles in order to retether. Necessary for SANDS to get underway to search for airdrop. 0900-1600W Airdrop search. 1300W Aircraft returns to assist in search. 1500W Package sighted by aircraft. SANDS vectored to position. Smoke flares dropped to assist in identifying location. Retrieved sealed container 27°12.8'N, 158°08.2'W. Returning to FLIP to reinstitute data link using sonobuoy transmitter. 1600W RADFORD reports transducer can be back on line by 2100W. Established COMEX at 2100W. 1700W Lying to with FLIP bearing 225°T at 1.0 nm. 1757W Bow thruster being employed to maintain station at 0.5 nm from the port side of FLIP. One engine in on bow thruster and other engine in on main propulsion. 1915W Finished calibrating with FLIP. Sonobuoy telemetry now being employed. It is important that the ships not separate more than 0.5 nm and that SANDS keep on the port side of FLIP. Requirements because of power in sonobuoy transmitter and location of antenna on FLIP. The sonobuoy link is noisier than the previous rf telemetry link. Broad-band noise is -43db/1 V when no channels are being modulated. Modulating a channel causes the broad-band noise of the unmodulated channel to increase to -35 db/1 V. RADFORD at ALFA plus 500 nm at 2000W. Transducer will be energized at 2100W. SOA now 10 knots. Delay in rigging transducer until 2200W. No shots have been detonated since the transducer went off the line since safety precautions preclude working on transducer and handling explosives at the same time. 2200W Shut down No. 1 main engine, No. 2 main on bow thruster. 2340W RADFORD gives ETA Point BRAVO 1 September, 1430W. Considerable noise being experienced with FLIP hydrophones. A rasping noise like cables sliding against object.

Wind 090°-135°T/8-10 knots. Waves 090°-135°T/1-2 ft. Swell 110°-135°T/3-4 ft.

31 August – Saturday

Lying to with No. 2 engine on bow thruster. FLIP at 0.3 nm. 0001W RADFORD reports position at ALFA plus 527 nm. Just prior to receiving shot 326 at approximately 1450W a test was made to determine the contribution of the bow thruster to noise being picked up in FLIP hydrophones. No significant difference noted as bow thruster was stopped. H-5 one-third-octave phone had perhaps a 1-2 db change although it had normally been varying and it is uncertain whether this change was a function of the bow thruster condition or not. Hydrophone 6 is about 6-8 db higher than it had been when tethered. 1545W FLIP reports that the center of the SOFAR axis is about 820-840 meters. The array is distributed over 700-770 meters. The shot depth is 760 meters. Elected to stay at this receiving depth rather than change at this time. Will plan to change near the end of the phase to see if propagation is any different. 1815W Hydrophone 6 sounds very noisy and may be blocking. Requested FLIP to replace this with another phone. FLIP replaced with H-4 prior to the 1845-1945W data period. 2200W Ship transferred from main generator to gas turbine to furnish power to bow propulsion unit. Purpose is to test ambient noise from SANDS' main power plant.

Wind 090°-130°T/8-12 knots. Waves 090°-130°T/1-2 ft. Swell 110°-130°T/2-3 ft.

1 September – Sunday

Lying to using gas turbine on bow thruster. FLIP 0.3-0.5 nm away. 0100W Shut off bow propulsion to see if any change could be detected on FLIP hydrophones. None noted. 0530W Gas turbine secured. Bow thruster on main engine. 0930W No. 1 engine to main propulsion, No. 2 engine to bow thruster. 1005W Approaching FLIP to re-tether. 1025W Hardwire and double tether line passed to FLIP. 1139W Slow ahead on main propulsion (50 rpm), 300 rpm on bow thruster. 1218W Bow thruster to 400 rpm. 1200W Birdy chirp on H-2, not noted on other phones. 1425W Shortened telemetry cable by 200 meters. 1400 meters now out. 1500W RADFORD reports now in position BRAVO. 1900W FLIP reports no tilt on array indicated (less than 5°). 2118W Noise decreased about 5 db on one-third-octave, 180-Hz, and 1-Hz filters. Slight decrease noted in the broad-band Sanborn trace. Bow thruster had been at 400 rpm and lost excitation momentarily. It appears that when the bow thruster exceeds 300 rpm in the tethered mode, it can be seen on the FLIP hydrophones. 2230W RADFORD reports 2200W position as BRAVO plus 75 nm.

Wind 110°-120°T/8-15 knots. Waves 110°-120°T/2-3 ft. Swell 110°-120°T/3-4 ft.

2 September – Monday

0001W Main propulsion 50 rpm. Bow thruster 400 rpm. FLIP 0.5 nm. 0300W FLIP experiencing problems with array. Signals shorted out. FLIP retrieved array and removed hydrophone H-5. Problem still not solved. FLIP also experiencing mechanical difficulties with the array. FLIP plans to haul in array, flip to horizontal, and investigate problems. 0900W Main propulsion to 40 rpm. 0930W Requested RADFORD to return to 0400W posit because data indicated that ship probably at the transitional area of the SOFAR channel when FLIP went off the line. RADFORD will be at the 0400W position at 1500W. 0939W FLIP released hardwire. 0942W Main engine stopped. 0945W Bow thruster stopped. 0955W Tether released by FLIP. 1120W SANDS maneuvering in vicinity of FLIP while FLIP effects repairs to array. 1400W Radio contact with FLIP indicates it expects to have problems solved and be operational by 1800W. Established 1800W COMEX with RADFORD. From their 0400W position RADFORD indicates that fuel supply prevents it from having any more delays. 1816W Passed tether line and hardwire to FLIP. 1838W Slow ahead on main propulsion, 300 rpm on bow thruster. 1600 meters of hardwire out. FLIP 0.5 nm. 1850W Standing by FLIP waiting to pass tether line and hardwire. 1900W Changed hydrophone arrangements from 1, 5, 2, 4, 8 to 1, 7, 2, 4, 8. 1920W Completed paying out tether line and hardwire, and completed calibrations. 1945W Distant strangers being heard occasionally. Hydrophone arrangements so far have been: 1, 5, 3, 7, 8; 1, 5, 2, 6, 8; 1, 7, 2, 4, 8. 2300W High 60-Hz interference being observed on H-7 and H-4 from FLIP. Other channels have it, but not as badly. Refer to lofargram. FLIP reports seeing this interference on the inputs to modulators.

Wind 130°-160°T/8-12 knots. Waves 130°-160°T/2-4 ft. Swell 130°-150°T/3-5 ft.

3 September – Tuesday

FLIP 0.5 nm. Double tether line. Main propulsion 50 rpm. Bow thruster 300 rpm.

0110W H-2 acting up. Has a very high noise level. H-7 and H-4 have high background interference which has settled to around 52 Hz. 0135W FLIP shutting down briefly to do some rewiring to help noise problem. 0215W FLIP indicates noise coming up hydrophone cable and nothing can be done to eliminate it without completely shutting down. 0800W Main propulsion to 25 rpm. 0823W Commenced reducing bow thruster by 25 rpm increments. 0832W Resumed 300 rpm on bow thruster. 1350W Velocimeter cast. 1520W FLIP reports H-5 inoperative. 1928W Velocimeter retrieved.

Wind 135°-180°T/8-12 knots. Waves 135°-180°T/2-3 ft. Swell 135°-160°T/3-4 ft.

4 September – Wednesday

Maintaining position with FLIP as before. Main propulsion 50 rpm. Bow thruster 300 rpm. 0100W Note ambient noise change in H-8, 31 Hz for period 2100W. Lofargram also shows this. 1025W Stopping main engines. Shutting down No. 1 main engine. 1040W Stop bow thruster, slow ahead 50 rpm on No. 1 main. 1102W Stop main engines. 1106W Slow ahead 50 rpm on main engine, 300 rpm on bow thruster. 1128W Stop main engines. 1132W Stop bow thruster. 1200W Main propulsion 50 rpm, bow thruster 300 rpm. 1312W Lowering velocimeter. 1330W FLIP lowering array to coincide with SOFAR axis. 1345W FLIP reports array at depth (800-870 meters). 1400W FLIP replacing H-2 with H-6 on the telemetry link to SANDS. 1412W Ran controlled noise tests as follows: Condition 1: 1412W Main generator at 50 rpm. Bow thruster at 300 rpm on main engine. Condition 2: 1415W Main engine at 50 rpm. Bow thruster and one main engine secured. Condition 3: 1427W Bow thruster at 400 rpm on gas turbine. Both main engines secured. Condition 4: 1432W Bow thruster at 250 rpm on gas turbine. Both main engines secured. Condition 5: 1436W Bow thruster off. Gas turbine secured. Both main engines secured. Only two ship service generators running. 1445W Both main engines on line. Main propulsion 50 rpm, bow thruster 300 rpm. Stranger just before shot 778 and 780. 2040W Reducing speed from 50 to 30 rpm to note any differences in line structure on H-8 which started about 1920W. No change noted. 2128W Main propulsion to 50 rpm. 2200W RADFORD reports difficulties with Ling amplifier and are off the line. RADFORD requested to stay on station for 1 hr to repair Ling. If unsuccessful will initiate program modification IIA, that is shots on a 15-min sequence rather than an hourly sequence.

Wind 160°-180°T/6-10 knots. Waves 160°-180°T/1-2 ft. Swell 090°-180°T/3 ft.

5 September – Thursday

From 2340W last night until 0130W the CW projector was off for repair of power amplifier. 0130W Switched to program modification IIA. 0610W FINEX with receipt of last transmissions from RADFORD at 500-fm curve south of point CHARLIE. 0930W Completed final calibration of FLIP hydrophones. Retrieved hardwire link and tethering lines from FLIP and underway for Honolulu at 1100W.

Wind – calm; Seas – smooth.

6 September – Friday

Underway for Honolulu. 2000W Arrived Pier 27 Honolulu ending measurements of PARKA Phases 1 and 2 aboard SANDS.

Appendix D (C)
ACOUSTIC DATA ACQUISITION ABOARD FLIP

F. N. Spiess and W. Whitney
Marine Physical Laboratory
Scripps Institution of Oceanography

1. Objectives

Participation of the Marine Physical Laboratory group, utilizing FLIP and PACIFIC APOLLO, was directed toward two objectives. One was to provide the U.S. Navy Underwater Sound Laboratory personnel on SANDS with raw data for real time processing to produce propagation loss data. The signals from five hydrophones were provided to them in this context. The other objective was to accumulate information for our own studies of sound propagation. For this purpose data were recorded in various forms (to be described below) relevant to analysis of short time fluctuations of received signal level and to studies of coherence and effective direction of arrival (in the vertical) as viewed at a hydrophone array at the deep sound channel axis. In view of the limited computer facilities available on board FLIP no attempt was made to do data reduction in real time. Limited portions were, however, monitored, analyzed on board, and are reported below.

2. The Hydrophone System

Inherent in the use of suspended hydrophones is the possibility of strumming of the suspension lines. The flow of water over the connecting wire leading from the hydrophone to the platform or vessel from which it is connected produces a series of spectral components in the signal which depend upon the water velocity, size of cable, and length of cable. The result of this strumming can be quite disastrous, particularly below, say, 500 Hz. The resultant noise output from the hydrophone can be many orders of magnitude greater than the ambient sea noise. In order to produce a working system the hydrophones suspended below FLIP were mounted through mechanical, low-pass filters in frames on the suspension line. While this isolation was not complete, the units did, in most cases, provide usable signals.

The geometry of the system is shown in Figure D-1. Hydrophone 1 was mounted at the bottom of FLIP and wired directly up into the lab space. Hydrophones 2 through 7 constituted a non-uniform array at approximately the sound channel axis. The individual hydrophone outputs were available topside via the hydrophone telemetry system. Hydrophone 8 was located approximately 2440 meters below the array, and its output telemetered up the same wire as the other hydrophones.

The hydrophones used for H-1 through H-7 were Clevite CS-131ABB. These units have a depth capability of 6000 feet. Single units contain a sensor having a nominal sensitivity of -94 dB re 1V/μbar and a preamplifier with a nominal gain of 35 dB. The frequency response of any unit is from 0.5 Hz to 150 kHz ±2 dB. Hydrophone 8 was a Clevite CS-132ADB (PSW) having a depth capability of

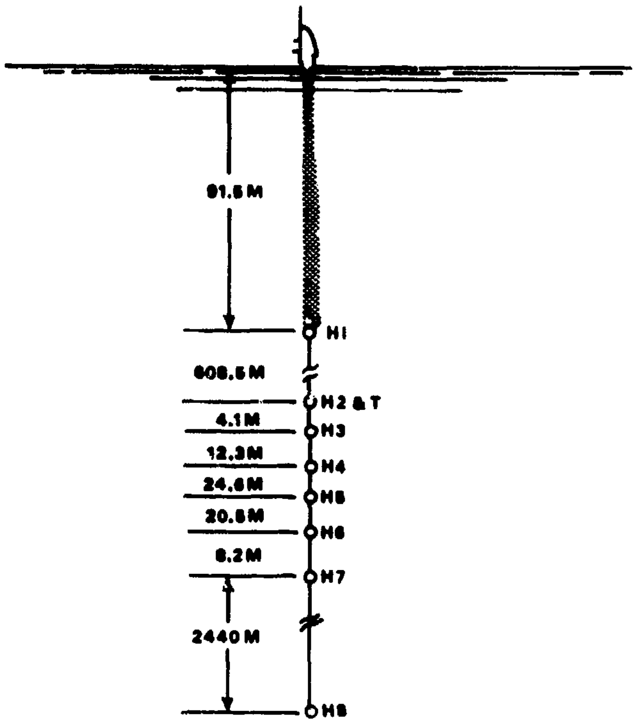


Fig. D-1 – Flip hydrophone system geometry (C)

20,000 feet. Electrically it is the same as the other hydrophones. All units were calibrated relative to one unit at 80 Hz and the reference unit calibrated at NURDC prior to the experiment. Variation in their overall outputs amounted to about 4 dB. Each unit was fitted with flexible electrical cable to plug into the appropriate telemetry-modulator package.

The hydrophone telemetry system consisted of a telemetry-modulator package for each unit on the line. Each telemetry-modulator output was then added through an internal summing resistor to other units on the suspension cable which was double-armored containing an RG58 coaxial electrical cable. This electrical cable contained the DC power to operate the units plus the sums of all signals from the units on the line. Each unit on the line was assigned a unique center frequency and a 20 kHz passband for the FM signal produced by the telemetry-modulator. The telemetry-modulator package contained a low-pass filter, nominally 2 kHz, a multivibrator FM modulator, an assigned band-pass filter, and a power amplifier. A single RC filter at the input to the modulator provided a low frequency cutoff of nominally 20 Hz. The system gain exclusive of the hydrophone pre-amplifier was checked by replacing the hydrophone unit with a signal generator and driving the telemetry-modulator package with an appropriate signal level while it was on deck prior to lowering.

The topside equipment for the hydrophone telemetry system consisted of a set of bandpass filters matched to those below to separate out the individual FM modulated signal bands, and a set of FM demodulators followed by output amplifiers for gain and buffering purposes. The overload point of the system was set by the output limit of these amplifiers. This overload point varied among these amplifiers between 16-20 volts so a "safe" overload point of 10 volts peak was used. The overall gains of the units were set such that the broadband sea noise (20 Hz to 2 kHz) rms output level for a sea state between 1 and 2 was 40 dB below the peak overload limit of 10 volts. This condition was only approximately met due to the variation in the sea noise and strumming components.

3. The Telemetry System FLIP/SANDS

The components of this system were commercial units obtained from Data-Control Systems, Inc. On FLIP, were located five FM subcarrier modulators type GOV-4 and one summing amplifier type GSA-3. On SANDS, was located a Series 400 receiver with appropriate tuning and IF components, and five type GFD13 FM subcarrier demodulators with appropriate tuning units and low-pass filters.

The outputs of five of the buffer amplifiers, on FLIP, were patched through fixed attenuators to the subcarrier modulators such that each hydrophone's signal was assigned a unique subcarrier band. The outputs of these modulators were added in the summing amplifier to produce one signal for transmission to SANDS.

Initially the above summed output was transmitted to SANDS via a 238 MHz FM transmitter obtained from Data Communications, Inc. This mode of operation proved to be successful for a limited time. Two of these transmitters were acquired for this experiment, however both failed. After the failure of the FM transmitters a hard-wire link to SANDS was successfully attempted. Here the output of the summing amplifier was amplified to drive the line. This mode of operation was used for the major part of the remainder of the experiment. Another mode of operation was used for a short time where the transmitter portion of a sonobuoy was used to transmit to SANDS. Outside of some problems with nulls in the radiation pattern from the buoy on FLIP, this mode was successful.

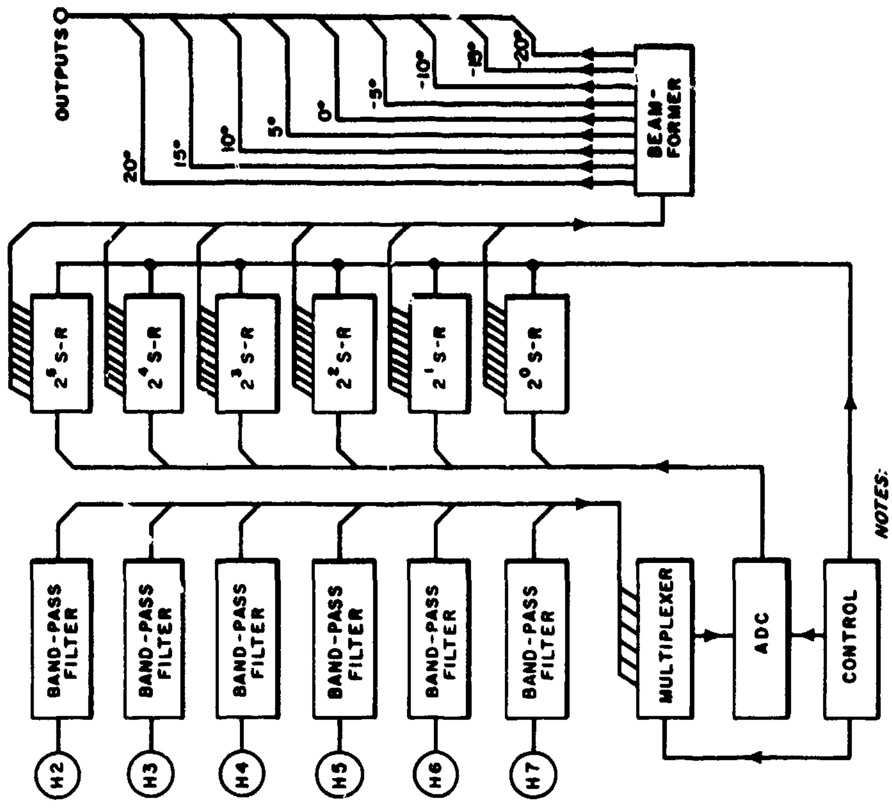
4. Preliminary Results Obtained At Sea

Ten second average samples of the narrow band propagation loss for a hydrophone near the sound-channel axis were computed and plotted for time intervals of 13-14 minutes at five ranges. These plots, shown in Figure D-7 are indicative of the fluctuations involved. Relative frequency of occurrence curves for approximately 500 samples taken for two of the above ranges are shown in Figures D-8 and D-9.

The narrow band signal was processed on FLIP through a set of 0.2 Hz wide filters centered at 500 Hz by heterodyning the signal to this frequency. The resultant signal-to-noise ratio out of these units was generally better than 20 dB. This leads to the use of a phase detector between the outputs of two narrow band filters associated with two hydrophones that were one wavelength apart to determine the effective acoustic angle of arrival in the vertical. At 1500 miles range an analysis was made where data related to a signal-to-noise ratio of 26 dB (or higher) was processed. Preliminary results of this analysis indicate that arrival angles are generally within the ±36° sector.

5. Data Recording and Processing

In order to provide a "back-up" capability for the digital processing and flexibility in the choice of material to be processed, two, 7-channel magnetic tape recorders were provided for nearly continuous analog recording of appropriately selected hydrophone outputs. The instrumentation shown in Figures D-2, D-3, D-4, D-5, and D-6 provided for the computation and digital recording of signal plus noise energy and noise energy in certain frequency bands from certain hydrophones. These recordings will be processed for propagation-loss and propagation-loss fluctuation results. A rather new and interesting technique will be used. That is, the spectrum of the fluctuation will be computed by subtracting off the average value for appropriately long blocks of data and computing the spectrum for the remaining AC values.



NOTES:
1. BAND-PASS FILTERS WILL BE 1/3 OCTAVE COVERING APPROPRIATE CW SIGNAL.
2. OUTPUTS (A) TO INPUTS OF SHOT ENERGY ANGULAR DISTRIBUTION PROCESSOR (B) TO INPUTS OF NARROW BAND FILTERS FOR CW PROCESSING.

Fig. D-3 — Block diagram of signal processing (U)

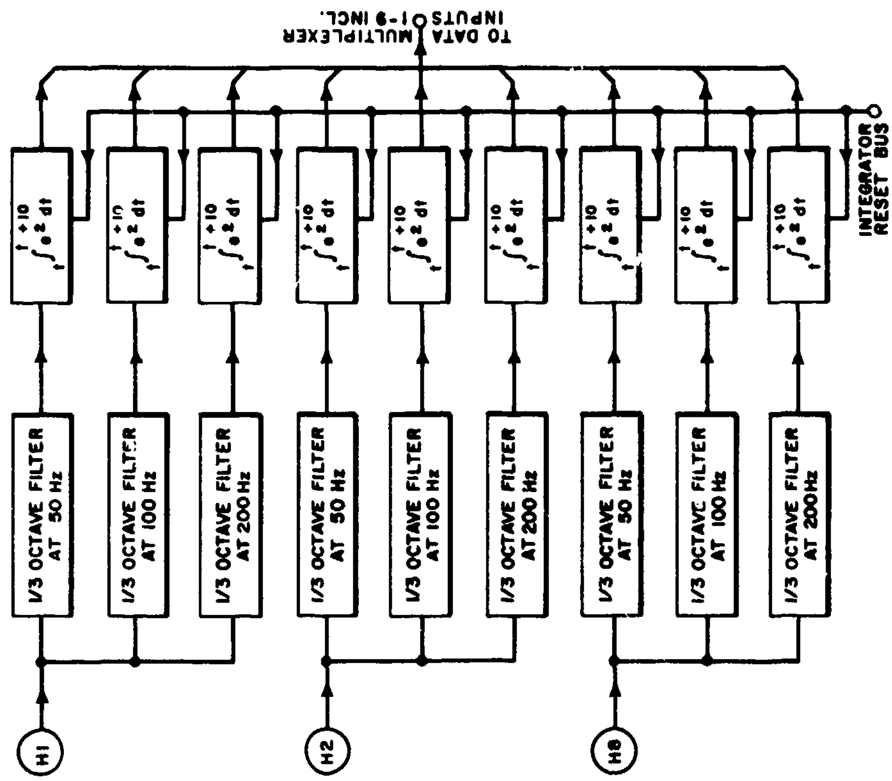


Fig. D-2 — Block diagram of signal processing (U)

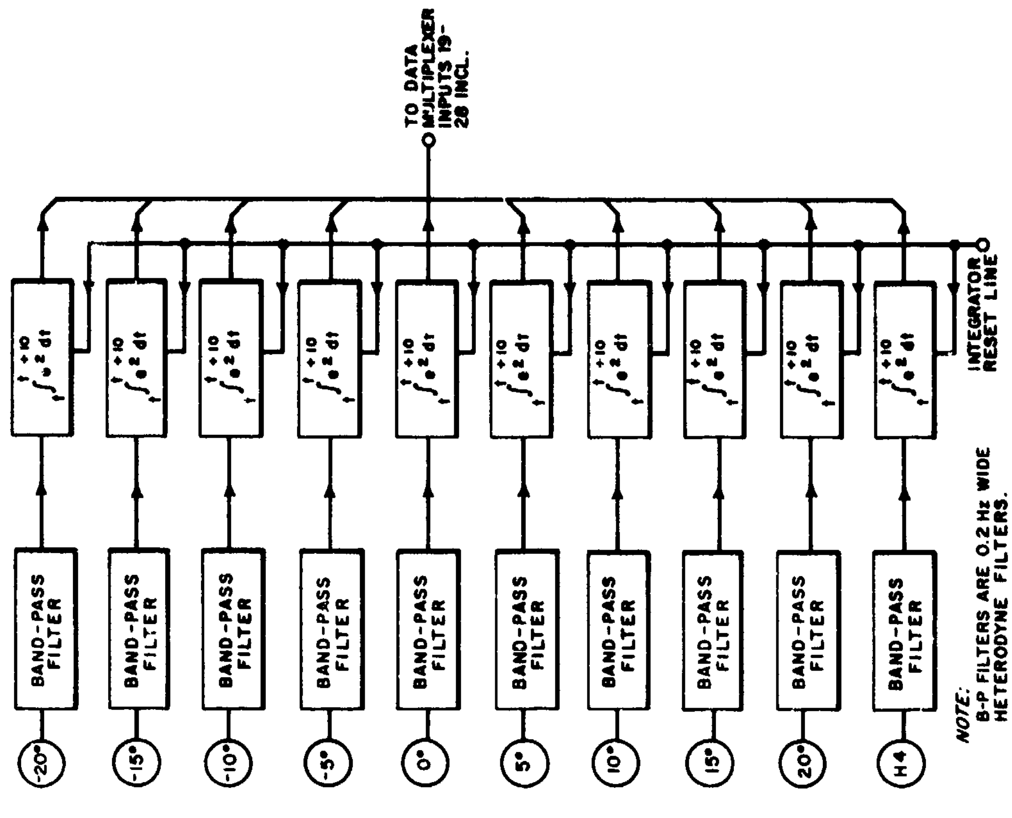


Fig. D-5 – Block diagram of signal processing (U)

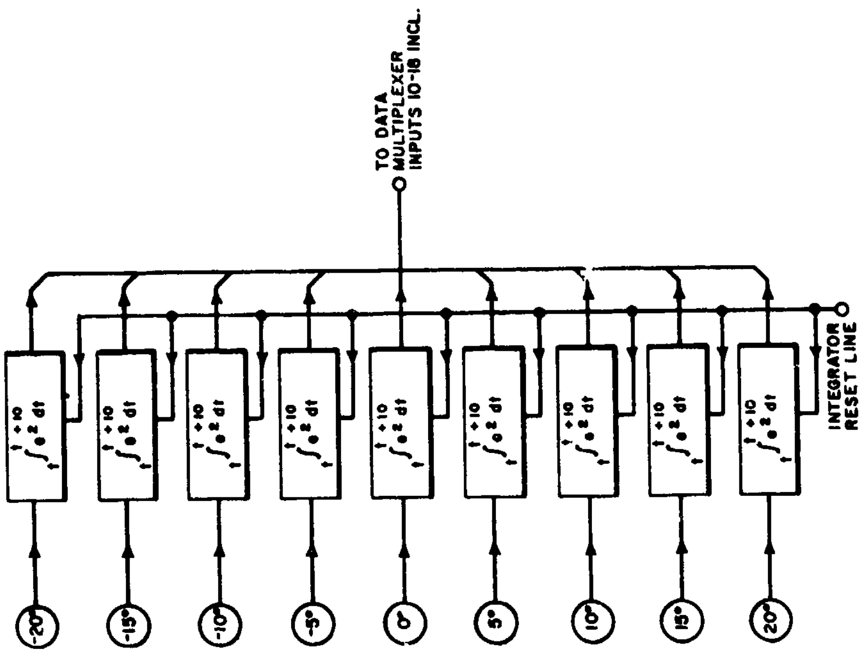


Fig. D-4 – Block diagram of signal processing (U)

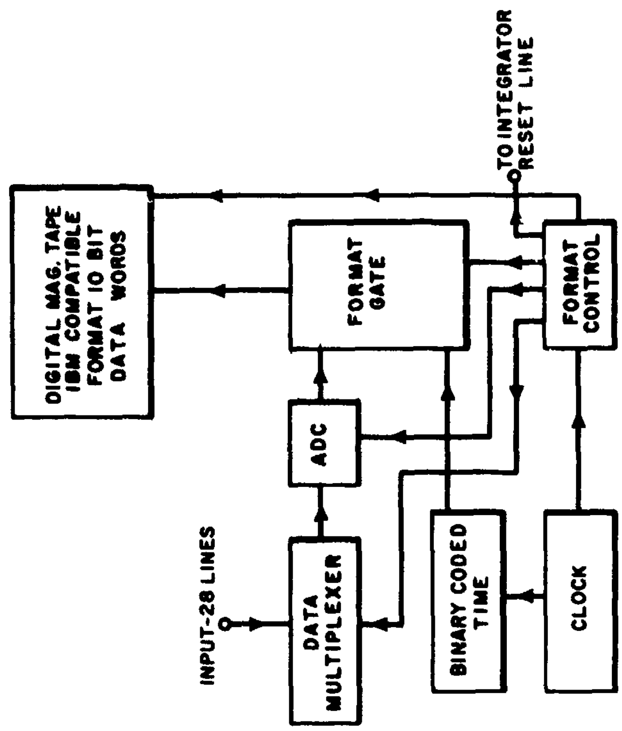


Fig. D-6 – Plan diagram of data input (U)

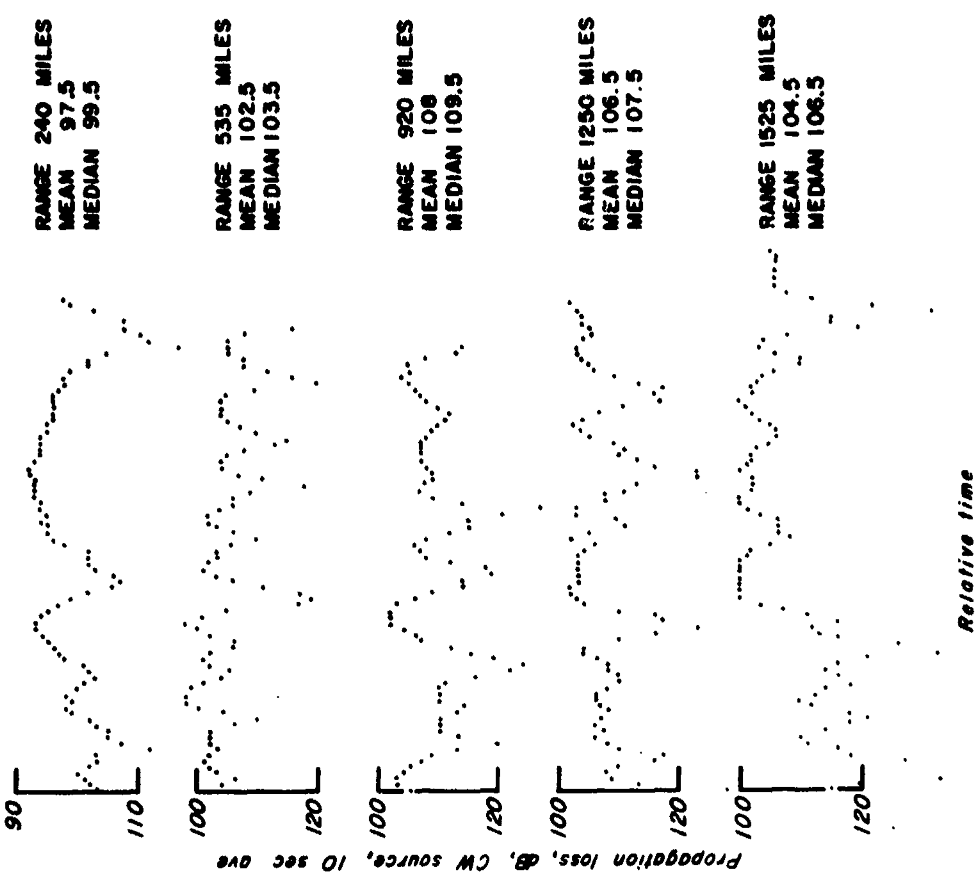


Fig. D-7 – Propagation loss vs time (C)

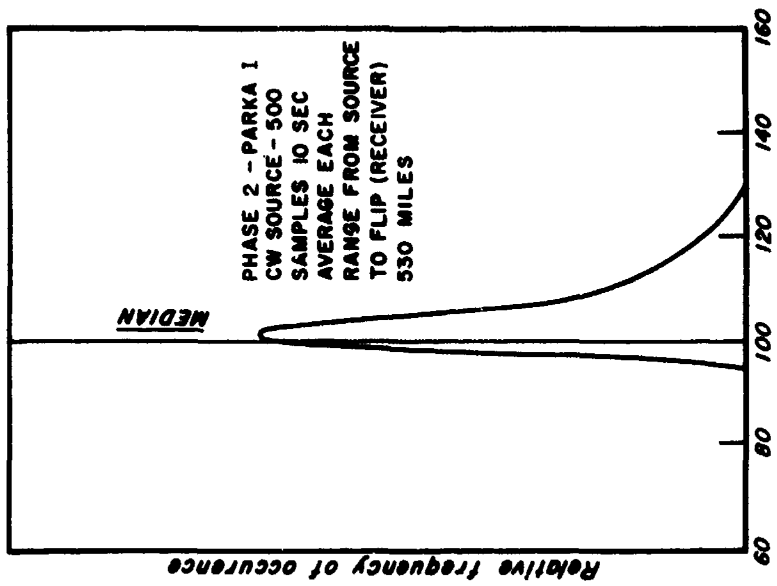


Fig. D-8 – Frequency of occurrence vs propagation loss (C)

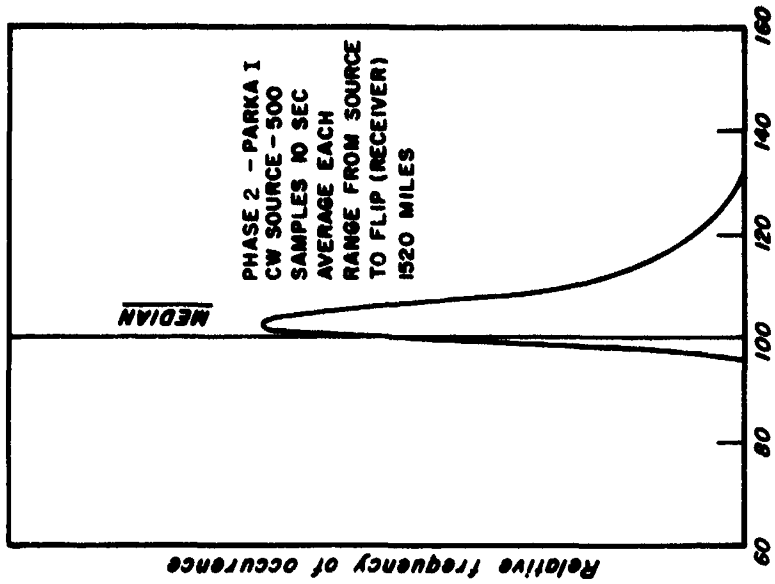


Fig. D-9 – Frequency of occurrence vs propagation loss (C)

Appendix E (C)

ACOUSTIC DATA PROCESSING ABOARD SANDS

R. W. Hasse and R. L. Martin
Navy Underwater Sound Laboratory

1. Introduction

The U.S. Navy Underwater Sound Laboratory fulfilled a number of functions in the PARKA I Experiment. These included the following:

a. Providing the Deputy Chief Scientist.

b. Outfitting and operating USNS SANDS (AGOR-6) as the principal acoustic data acquisition and analysis station.

c. Instrumenting and manning listening hydrophones at the Pacific Missile Range (PMR), Kaneohe, during Phases 1 and 2.

d. Outfitting and manning USS RADFORD (DD-446) as source ship during Phase 2.

e. Calibrating the acoustic sources used by RADFORD and R/V ROBERT D. CONRAD.

f. Providing oceanographic equipment for outfitting M/V PACIFIC APOLLO.

2. Deputy Chief Scientist

The Deputy Chief Scientist worked closely with the Chief Scientist, Project Coordinator, and participating organizations in defining the experiment, identifying critical parameters, and developing an implementation plan to meet the objectives of PARKA I. During the PARKA I Experiment he was aboard SANDS to provide in-situ assessment and control of the acoustic data being obtained.

3. USNS SANDS – Principal Acoustic Processing Center

a. General

SANDS' primary function was to serve as the principal acoustic processing center. A secondary function was to take daily velocimeter readings to assist in meeting the environmental requirements of the exercise.

The original employment planned for SANDS in the PARKA I Experiment was as the data acquisition and analysis center for the bottom-mounted tripod array, SEA SPIDER. When it became apparent that SEA SPIDER would not be available in time for the exercise, FLIP was relocated from the originally designated spot farther north along the PARKA I track to the location originally specified for SEA SPIDER. SANDS continued to perform its function of data acquisition and analysis, except that now, in lieu of SEA SPIDER, FLIP was the supporting platform for the listening hydrophones. In order to maintain a relatively constant position, SANDS deep anchored with FLIP tethered to it. The geometry for the receiving-processing platforms is shown in Fig. E-1. SANDS was moored in water 18,000 ft deep at 27°30′N, 157°50′W. With eight hydrophones at the depths indicated in the figure, FLIP was tethered to SANDS by 1 mile of 7/8 in., Sampson double-braid line. This line has a breaking strength of 20,800 lb and consists of a central core of nylon sur-

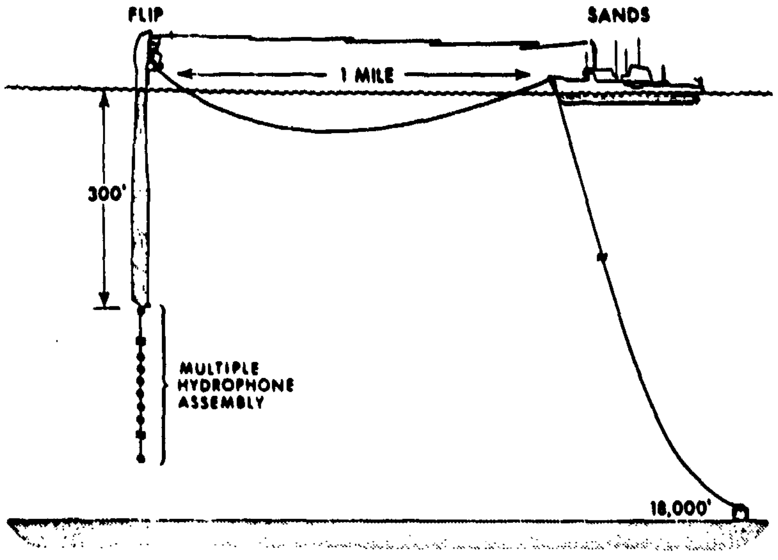


Fig. E-1 – FLIP/SANDS operational profile (U)

rounded by a braided sheath of polypropylene. The shallowest hydrophone, designated H-1, was on its own cable located at the end of FLIP 300 ft below the surface. The remaining seven hydrophones were multiplexed on a single coaxial cable. Hydrophones H-2 through H-7 extended over an interval of 230 ft with the contiguous spacings between units being 14, 40, 80, 70, and 26 ft, respectively. For the acoustic measurements these six hydrophones were placed in the sound channel axis which was approximately at 2500 ft. Hydrophone H-8 was located at a depth of 10,800 ft.

An FM telemetry system with a carrier frequency of 238 MHz and five subcarriers with frequencies of 50, 80, 110, 140, and 170 kHz from the carrier permitted transmitting the analog output from any five of FLIP's eight hydrophones to SANDS for processing. The carrier bandwidth of the FM link was 390 kHz wide, and the intelligence band of each subcarrier was 4 kHz wide; thus, a 50 db dynamic range was provided for acoustic signals in the 20 to 2000 Hz frequency range.

Aboard SANDS was an acquisition and computational facility, the heart of which was a UNIVAC 1230 computer groomed to compute in real time a number of acoustic parameters desired as outputs from the PARKA I experiment. An array of analog recording equipments also was aboard SANDS, both as a backup in case of computer failure and for the recording of other information that would require extensive post-exercise interpretation and analysis.

Figure E-2 is a block diagram of the instrumentation suite aboard SANDS. The ENVIRONMENTAL SYSTEM provided the capability of measuring sound velocity as a function of depth through the full depth of the water column. The velocimeter employed was the NUS TR-4, which has an accuracy of 0.15 meters/second. Depth was determined by using a CEC strain gauge as a pressure sensing element in a USL-designed bridge circuit employing a Teledynamics voltage-to-frequency converter. The system provided direct digital printout of sound velocity in meters/second versus depth in meters. The depth equivalent pressure readings were accurate to 0.5 percent.

The ANALOG RECORDING SYSTEM was designed to provide a capability of measur-

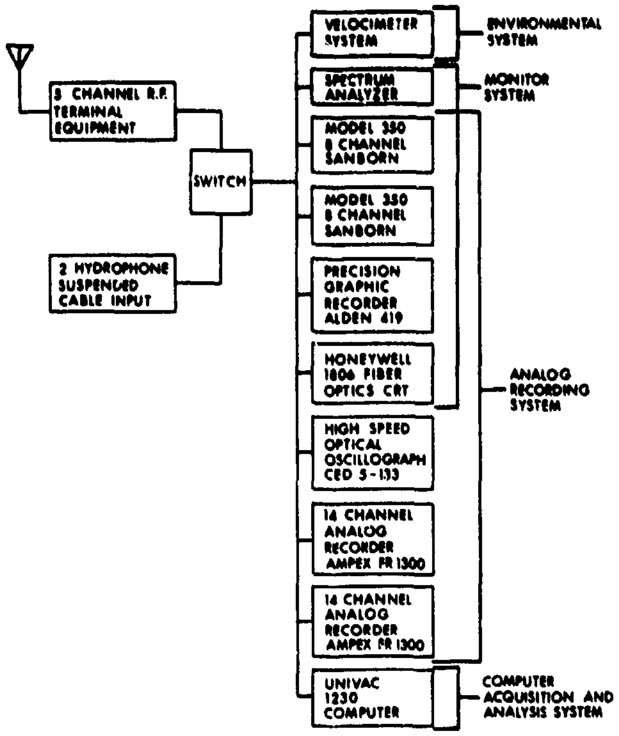


Fig. E-2 – Instrumentation aboard the USNS SANDS (AGOR-6) (U)

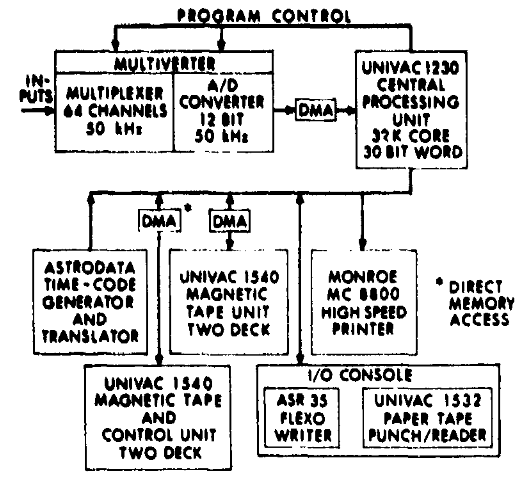


Fig. E-3 – General purpose computer and data acquisition system (U)

ing received levels of acoustic signals and, with higher speed instrumentation, a capability for multipath resolution and the ability to measure differences of arrival time on various receiving hydrophones. The MONITOR SYSTEM provided the capability of checking the calibration and operation of the instrumentation suite. Specifically, it allowed a continual real-time surveillance of the computer's response to analog signal inputs. This permitted an on-line assessment of various decision criteria in the computer program, such as presence or absence of signal, signal duration time, identification of non-PARKA signal sources, and synchronization of the computer input aperture with the desired signal.

The computer acquisition and analysis system consisted of a UNIVAC 1230 general-purpose computer with a multichannel A/D input capability. A number of considerations went into deciding how this acquisition and computing facility would be configured to meet the needs of the PARKA I Experiment. The guidelines developed were as follows:

(1) Acoustic band of interest – 20 to 2000 Hz.

(2) Frequency bandwidths – one-third octave, but not less than 20 Hz for charges.

(3) At least three receiving depths – one shallow, one in the SOFAR axis, and one well below the axis. (Depths were chosen to test predictive capabilities for three significantly different receiving situations.)

(4) Sampling period for a given filtered signal to extend to 15 seconds.

(5) Acoustic sources – explosives, an airgun, and a CW transducer.

The general-purpose computer together with the various input-output devices that make up the data acquisition system on SANDS is shown in Fig. E-3. The central processing unit has a 30-bit-word size, but it is capable of operating in a mode that permits addressing half-words, thereby effectively doubling the core size to 64 K. The multiplexer and A/D converter operate at 50 kHz and can serially sample up to 64 channels. Each sample

results in a 12-bit word that accesses main memory directly. Program control can allow either sequential or random accessing of the input channels. The four magnetic tape decks operate at 120 in/sec with data densities of 200, 556, or 800 bits/in. The Monroe printer also can be used as a plotter. It increments at 100 steps/sec and prints 80 characters/step by utilizing fiber optics to record on photosensitive paper. The I/O console contains the flexowriter and paper-tape read/punch. The flexowriter runs at 10 characters/sec, and the paper-tape unit produces a punched paper tape at 100 characters/sec and reads such tapes at 300 characters/sec. The Astrodata time code generator and translator was integrated into the system to provide time indexing with respect to a standard, such as WWV.

Approximately 40 K 12-bit words were available for signal storage in the computer. Since sampling rate requirements increase with bandwidth, an arrangement which appeared attractive was to restrict real-time computer processing to frequencies not greater than 400 Hz. Frequencies above 400 Hz were not expected to be heard over the total track of the experiment. Employing one-third-octave filtered inputs to the computer permitted a maximum sampling rate of not over 250 samples/sec/channel. Thus, 10 input channels to the computer could be accommodated. The final selection of input channels is shown in Table E-I. With Table E-I as a guide, the data acquisition system was set up as shown in Fig. E-4.

The hydrophone outputs were telemetered to SANDS, where they were monitored and recorded on analog magnetic tape. Selected hydrophone outputs were filtered, envelope detected, multiplexed, and converted to digital form for inputting to the UNIVAC 1230 computer. When shots were used, octave filters

Table E-I (C)
Input Channels to the UNIVAC 1230 Computer

Phase	Hydrophones	Nominal Depth (ft)	Center Frequencies (Hz)
1	1	300	31.5, 100, 400
	2	2,500	31.5, 100, 200, 400
	8	10,800	31.5, 100, 400
2	1	300	31.5, 100, 200, 178(CW)
	2	2,500	31.5, 100, 200, 178(CW)
	3	2,500	178(CW)
	7	2,500	178(CW)
	8	10,800	31.5, 100, 200

were employed for analysis below 100 Hz and one-third-octave filters were used for 100 Hz and above. The 1-Hz filter was used only to process the CW signal. A time-code generator with an IRIG B format and a digital output was used to simultaneously record time on the analog tape and in the computer.

b. **Data Processing**

The software developed for the PARKA I Experiment included a calibration program, a noise calculation, several different computations on the sampled data, and a set of decision criteria that could be altered as desired. In addition to the actual sampled signal, the system had the following external inputs: a set of operator overrides on the computer decision process, a time base synchronized within milliseconds to WWV, and an index of source initiation instant.

Analog pen recordings of signal inputs to the acquisition system and capture responses of the system to the input signals were provided to assure the operator that no extraneous information was entering the system and that the desired signals were being sampled properly. Complete processed results were dis-

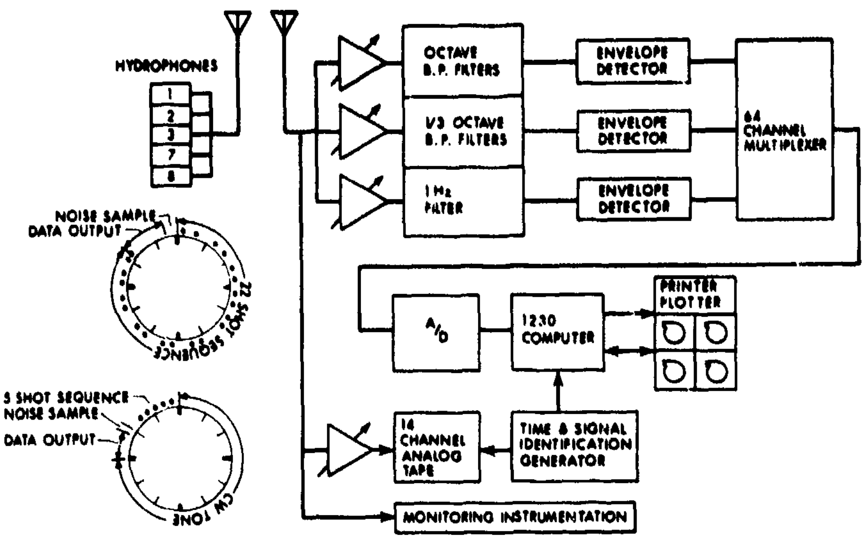


Fig. E-4 – Processing system for Pacific progagation measuıements (U)

played at regular intervals to provide a continual assessment of experiment progress.

Phase 1 of the experiment consisted of two explosive charges detonated every 5 min, as indicated on one of the two clocks shown in Fig. E-4. After the last shot of the hour, the remaining time was used for outputting data and obtaining a noise sample. The noise sample served two purposes: it provided the necessary information for making signal-to-noise (S/N) corrections for weak signals, and it provided the required information for establishing the decision criteria for determining the presence or absence of a signal to the computer. Before each shot transmission, a 1-kHz tone was transmitted from the source vessel over a radio link to SANDS. At the time of detonation, this tone was cut off in order to provide an indexing of initiation time. During each 5-min-noise-sample period, all processed data were outputted.

During Phase 2 of the experiment, five shots were detonated in a 10-min period each hour, as shown in Fig. E-4, and then a CW acoustic signal was initiated and continued for 45 min. The remaining 5 min of the hour were used for sampling ambient noise levels and for printing out computed results.

At the start of each phase and at regular intervals during the experiment, the system was calibrated at a number of frequencies by inserting CW signals at the inputs to the modulators on FLIP. On SANDS, the resultant signals were processed in the computer to obtain a calibration constant, which was referred to an equivalent pressure level in the water. All signals during the e. rcise were compared to these calibration constants to obtain instantaneous pressure levels. Also, at the start of the experiment, values of the source levels for the various sources involved and the attenuator settings for the various computations performed were set into the computer.

An executive program (Fig. E-5) controlled the collection, processing, storage, and outputting of all the data and results of computation. All data samples used in the various calculations were stored individually on a raw data tape, and all processed results were stored on a processed data tape. In addition, all processed data that were to be printed out hourly were temporarily stored on a scratch

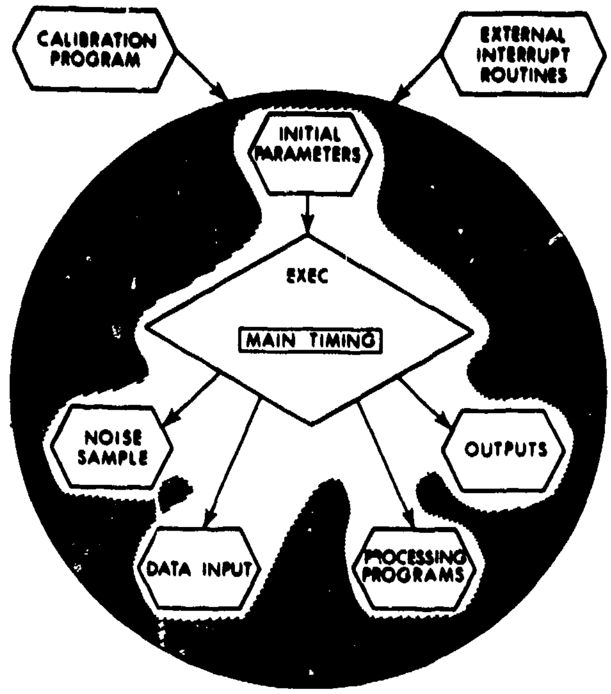


Fig. E-5 – Programming block diagram (U)

tape. A fourth tape unit was free for preventive maintenance and went on-line as soon as one of the other tape units required tape rewinding.

Figure E-6 shows the format of the tabulated output from the computer. This example is from Phase 2 of PARKA I. Similar results were printed out during Phase 1 using a somewhat different format. These print-outs occurred at the end of each hourly data set and contain information on time, shot number, range propagation loss, S/N ratios, and noise level. In the first column of the figure, the day of the month and time when the print-out occurred are listed at the top. Below this, there are three subcolumns: the first subcolumn contains the range to the source in hundreds of yards for each of the five shots that occurred during the hour; the second subcolumn reports the number of shots yet to be received, and the last subcolumn shows the shot number assigned to the event. Under these columns are the propagation loss and corresponding S/N ratios for the five shots observed at the output of each of ten hydrophone-filter combinations. At the top of this column, "Range in Hundreds of Yards" refers to the fifth (last) shot of the hour. The second column contains the propagation loss of the CW signal based on the average received level during each of nine 5-min intervals. This average is printed out for each of five hydrophones. Under "TABLE NOS" is the level in db//1 μbar for an integrated 15-sec-noise sample observed at the outputs of the ten filters used to process the shot data. Under "TABLE GSXIDB" is the noise level integrated for 30 sec at the output of the five 1-Hz filters used to process the CW signals. These noise levels were later reduced to spectrum levels.

To determine propagation loss, it was necessary to square and sum the information from each input buffer, compare the result with a calibration constant to obtain received pressure level in the water in dB//1 μbar, correct the received level as necessary for the influence of ambient noise as determined by the calculation of the S/N ratio, and subtract the correlated received level from the source level of the particular charge or projector used.

For processing shot information the sampling program was initiated 30 sec before a shot reception was anticipated. Data samples from each of the multiplexer channels were read into individual core buffers at a predetermined rate. The sampling rate normally employed 250 samples/sec, which corresponded to a real-time buffer of 15-sec duration. The sampling rate was selectable, and the only restriction was that the product of sample rate times sample time had to be a constant. Each buffer area contained 1875 30-bit memory locations (3750 locations when used in split-word modes). The 1230 computer has a con-

```
TIME
DAY      3
HOUR  16
MINUTE       14
SECOND       14
     26323.  4.  636.
     26431.  3.  637.
     26446.  2.  638.
     26477.  1.  639.
     26540.  0.  640.

TOTAL PROPAGATION LOSS  SN RATIO
RANGF IN HUNDRED YARDS :     26540.
      114.5  -9.6
      101.5  6.2
      106.5  3.3
      96.5  -6.7
      99.5  -3.7
      103.1  -6.7
      110.6  -10.3
      88.5  -2.5
      114.6  0.8
      103.7  10.2
      111.6  -6.7
      101.3  6.3
      105.8  4.0
      97.3  -7.6
      98.0  -2.2
      101.5  -5.1
      110.0  -9.7
      87.8  -1.8
      114.1  1.3
      104.7  9.2
      107.1  -5.1
      110.0  -5.1
      105.6  1.3
      114.8  -3.1
      118.5  -0.7
      117.1  1.2
      105.8  -7.6
      94.2  -2.2
      123.8  -10.3
      110.1  1.8
      111.8  -9.8
      103.5  1.3
      107.7  -0.7
      116.3  -7.6
      106.5  8.2
      110.2  5.1
      108.6  -8.2
      93.8  -1.8
      123.5  -7.8
      109.2  4.8
      110.5  -8.5
      106.0  -1.1
      109.8  -2.8
      111.2  -2.5
      106.7  8.0
      112.3  3.0
      110.2  -9.8
      94.2  -2.2
      125.6  -10.0
      110.5  3.6

PROP LOSS BASED ON 5 MIN AVGES
    117.1
    103.7
    109.8
    106.2
    113.6
    119.5
    105.6
    109.8
    105.8
    112.7
    119.5
    105.3
    111.7
    106.5
    108.8
    121.3
    104.5
    109.5
    107.1
    110.0
    121.1
    104.3
    110.2
    110.6
    115.2
    121.2
    104.2
    112.3
    104.1
    113.1
    121.2
    105.8
    108.2
    107.7
    113.0
    120.8
    106.7
    105.3
    107.6
    112.0
    121.1
    105.6
    110.5
    106.2
    114.7
END OF CW PERIOD
TABLI NOS
19
16
14
19
13
12
20
34
5
7
TABLF GSXIDB
6
-6
-9
-9
-11
```

Fig. E-6 – Tabulated data print-out (U)

tinuous data mode (CDM). In this mode, data are read into core assignments until the limit of the assignment is reached. When this limit is reached, the computer automatically recycles and continues writing over the previously recorded values. This process is continued until stopped by the executive routine. This capability permits the computer to be programmed with simple decision rules, which can be overridden or modified by a human operator.

At the start of each hour this sampling process continued indefinitely until a signal arrival exceeded a threshold level determined by the noise sample taken before the start of the hourly sequence. Once a threshold crossing had occurred, sampling normally would continue until the buffer was saturated with data received after the time of the threshold crossing. A decision that a signal was present occurred if at least six out of ten sampled values exceeded a number that was n times greater than the rms value of the noise sample. In practice, n was chosen to be 3, 4, or 5, which is equivalent to a peak signal-to-rms-noise ratio of 10, 12, or 14 db. The six out of ten criterion was chosen because the samples were not independent. Because of the multichannel input being used with the possibility of significantly different S/N ratios on the various channels, three input channels were sampled independently to provide threshold criteria. In some cases, the leading edge of a signal arrival might be very low in amplitude. One could, in these instances, elect to retain a few seconds of data history along with the information received after a threshold crossing was sensed up to the buffer memory capacity of 3750 samples/channel.

The acquisition sensitivity was synchronized with the expected signal arrival time in order to minimize the system's response to false alarms. The time for anticipating shot receptions during the hour was set relative to the time of the first signal reception. For these later signals, sampling started 30 sec before the time of the anticipated signal arrival and continued until a threshold crossing occurred or for 60 sec, whichever was shorter. If a reception occurred at any time during the 60-sec interval, sampling would continue for the pre-established sampling interval.

This entire process was monitored on a multichannel graphic recorder. The analog signals from each of the sensors being sampled were recorded on individual channels, and one channel was set aside for the display of external interrupts to the computer. Figures E-7 and E-8 display two of the analog monitoring channels along with the channel displaying the access aperture of the computer. Figure E-7 presents a 15-sec signal history starting at the time a decision was made that a signal was present. Figure E-8 is for the mode of operation where a 4-sec history was retained before the decision instant and then an additional 11-sec history was acquired. When sampling started, the computer indicated a one-level state on the recorder. When threshold was exceeded, a second-level state was indicated and a doorbell chime was activated to provide an audio indication of the event to the operator. When sampling was completed, a zero-level state was shown. The proper selection of sampling mode was made from inspection of the computer monitor display.

In addition to monitoring the overall sampling and decision making programs of the computer, the operator had the option of modifying or nullifying any decision made by the computer during the sampling period. If a false alarm occurred or if for any other reason it was desired that the data in the buffers be erased and that the 60-sec-sampling sequence

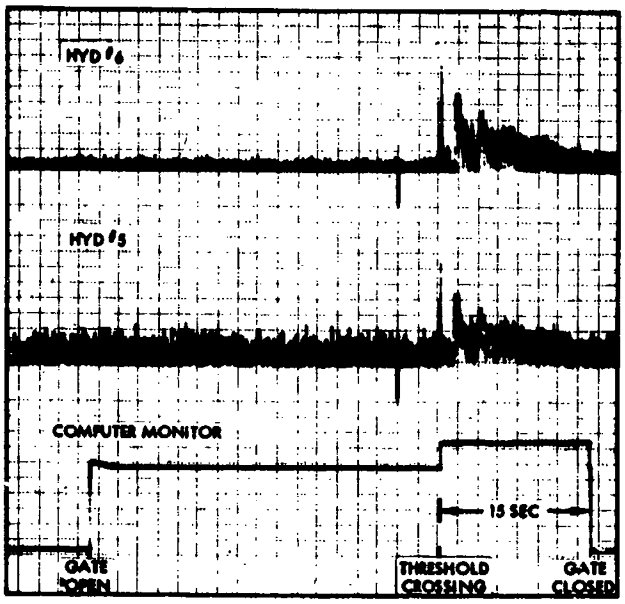


Fig. E-7 – Computer monitor display (U)

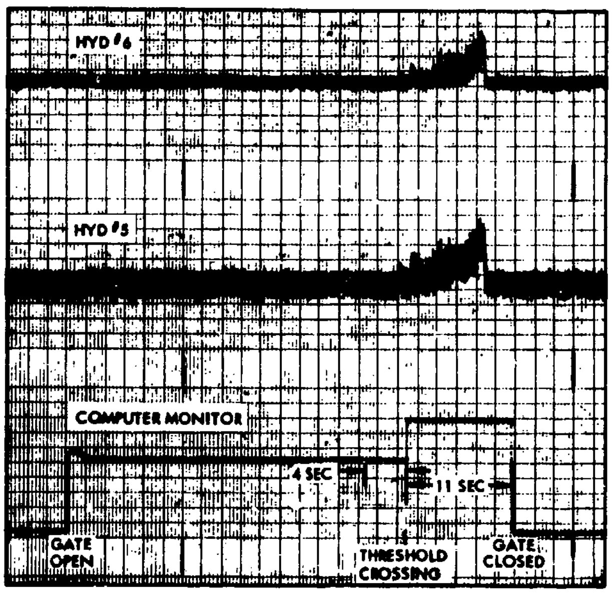


Fig. E-8 – Computer monitor display showing pre-decision point history, mode of operation (U)

be restarted, depressing an appropriate key on the teletype with the interrupt set allowed sampling to continue for a maximum of another 60 sec. If an arrival occurred without a computer acknowledgment, depressing a different key on the teletype forced sampling to terminate after an additional 5 sec, while the previous 10 sec of data were retained. Also, if synchronization were lost between source and receiving platform, the position of the sampling apertures could be advanced or retarded by two other keys on the teletype.

Various other interrupts could be used to allow retaking of a noise sample, and checking or changing constants could be used in any of the calculations. An additional interrupt was available to allow read-in of the time code generator when signal detonation occurred, as evidenced by the cutoff of the 1-kHz tone being transmitted over the HF link.

c. Checkout and Calibration of Processing System

Before commencing the PARKA I Experiment, it was necessary to ensure that the processing system aboard SANDS was operating properly. Because the computer was not installed aboard SANDS until 10 days before departure for Hawaii, it was necessary to complete all check-outs and calibrate the entire system while in transit between New London and Honolulu.

The energy calibrations of the processing systems were accomplished as follows:

(1) Each channel was excited using a 1-V RMS sine wave. The computer programs sampled this signal for 1 sec, squared and integrated the samples, and used the calculated results for a reference level.

(2) All channels were then pulsed in parallel with an exponential pulse having a 1-V peak amplitude and a 1-m/sec-time constant. Theoretical results for such a transient calibration have been derived by Hasse[1] and are

[1]R. W. Hasse, *Techniques and Systems Employed for the Measurement of Acoustic Propagation Loss Using Explosives As Sound Sources*, USL Report No. 486, 15 August 1960.

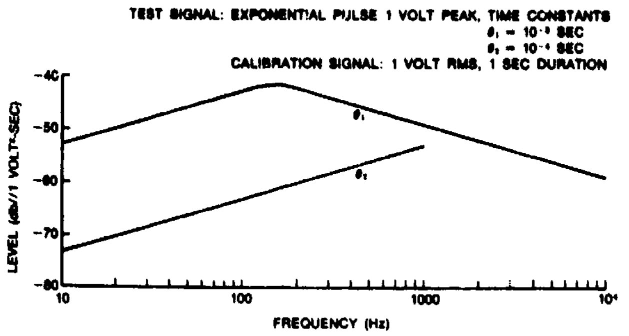


Fig. E-9—One-third-octave analysis of test signal (U)

shown in graphical form in Fig. E-9. This figure illustrates the level relative to the CW signal that can be expected at the output of a one-third-octave filter when the indicated exponential pulse occurs at the input.

(3) The exponential signal was mixed with noise in order to obtain a range of S/N ratios. In this manner, the programmed correction to the signal-plus-noise (S+N) data for the effect of noise could be ascertained. The correction curve programmed for the processing system is shown as a solid curve in Fig. E-10.

The abscissa is the measured (S+N)/N and the ordinate is the resultant S/N ratio after correction. The data points represent experimental results obtained in the course of program check-out. For all measured values less than 0.5 db the corrected value was assigned a S/N of -10 db. The difference between each measured and corresponding corrected S/N ratio was the amount by which the received signal level was corrected before calculating propagation loss.

Final experimental propagation results include only the data for which the corrected S/N ratios were -8 db or greater.

After the above computer routines were validated, the executive routines were checked out to ensure that the timing for the various computer routines used in Phase 1 and Phase 2 were compatible with the planned exercise.

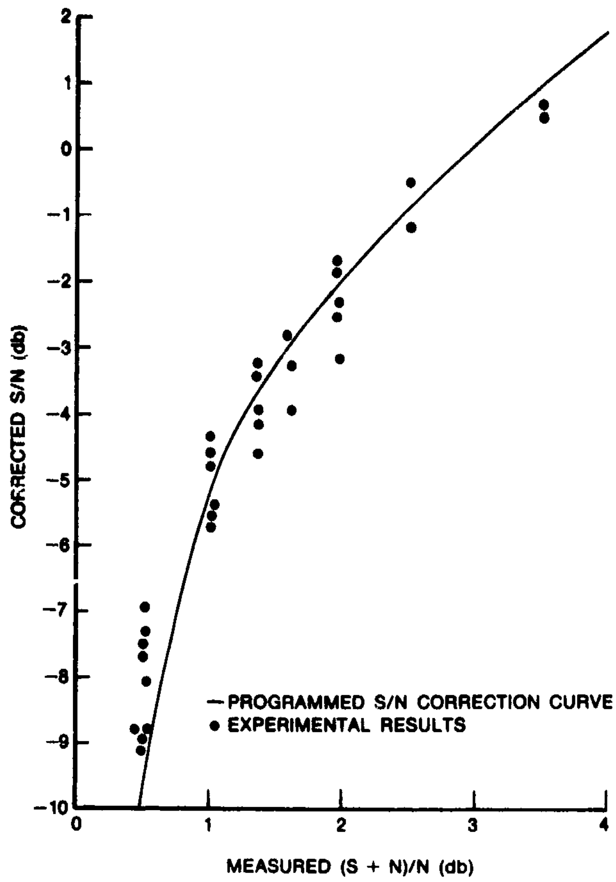


Fig. E-10 — Comparison of programmed and experimental S/N corrections (U)

The acoustic sequences were simulated using exponential pulses and CW tones where appropriate. Each phase of the experiment as described earlier was simulated for a total of 5 hr and the results of propagation loss, S/N ratio, noise level, received level, computer monitor display, and format of the computer outputs were checked. Finally, the entire analog and digital systems were operated in complete simulation of the experiment.

d. System Performance

The computer system employed on SANDS during the PARKA I Experiment dem-

onstrated that the results of acoustic measurements could be obtained and their validity assessed in real time over extended periods with a minimum of problems and maintenance. During the transit portion of the cruise from 1 July to 1 August, the only serious system problems encountered were due to a defective 4 K core module and parity errors on the magnetic tape units due to dirt accumulating on drag pads, which were provided to keep the magnetic tape wiped clean. With the replacement of the core and pads, no system problems that required taking the computer off-line occurred during the remainder of the summer. Several minor problems that were annoying occurred in the auxiliary units. Difficulty in adjusting the paper-tape read/punch sometimes resulted in several passes of the same paper tape before it was read in without error. The clutch of the teletype paper feed became worn, and the paper had to be pulled manually until a satisfactory repair was effected by using masking tape. The tensioner on the paper feed roller of the high-speed optical printer malfunctioned and caused the paper to rip at times. In addition, the high-voltage-power supply failed in one instance. Both problems were temporarily repaired by jury rigs until replacement parts could be obtained. The foregoing problems pointed up the need for having 100 percent spares on board, as well as a reprogramming capability, so that output formats and units can be changed as required. The system was shut down twice because of a malfunctioning air conditioner, and it faulted on three occasions when the ship switched power from the gas turbine to one of the ship service generators. The saline environment resulted in a need to change the magnetic tape drag pads every 3 weeks or so, but otherwise the marine atmosphere had no noticeable effects on system performance.

The approach used in providing programmed decision criteria, associated operator overrides, and monitoring techniques proved highly successful. In cases where the signal was repeatably strong and the background was highly variable, the threshold level could be set high enough to reduce the false alarm rate to a very small value. In cases where the signal strength was so low that threshold levels of 10 dB were required for automatic sampling, the reset capability using external interrupts was effective in correcting false alarms; thereby, a valid sample that would otherwise have been lost was provided. Table E-II summarizes the statistics from Phase 1 of the experiment.

The total number of false alarms that were not effectively negated was 52 out of 4154 signal receptions. An additional 30 shots were lost because of strangers that were either mixed in with the desired signal or mistaken for it. Only 38 false rests occurred. Although some were due to the signal never exceeding

Table E-II (U)
Error Statistics of Signal Receptions

False Alarms		False Rests	Out of Synchronization	Total	Total No. of Shots
Noise	Strangers				
52	30	38	97	217	4154

the threshold, most were attributed to late threshold crossings that were not identified or corrected in time to prevent partial loss of the signal sample. The largest single factor that resulted in lost data was due to the sampling aperture being out of synchronism with the shot reception. A total of 97 shot receptions was lost due to this single factor, which generally occurred if the first shot of the hour was a dud or was not detected or if a false alarm occurred in its place. The problem was compounded because the sampling sequence for successive shots in the hour was initiated in time relative to the first shot reception, and usually three or four arrivals would be missed before synchronization was reestablished with the shot sequence. Appropriate programming revisions could materially reduce this particular difficulty. The decision criteria, together with the operator override capability based on timely observation of the computer monitor system, resulted in a loss of about five percent of the data. Other losses of data occurred because of duds, failure of telemetry equipment, and excessive noise, and, in one case, computer failure resulted in a loss of 3 hr of data.

4. Pacific Missile Range (PMR) Kaneohe

The MILS Stations at the Pacific Missile Range Facility, Marine Corps Air Station, Kaneohe, Oahu, was manned during PARKA I Phases 1 and 2 for the purpose of recording the acoustic outputs of the MILS Hydrophones 14 and 16. These two hydrophones are close to one another, at a depth of 2070 ft on the northern slope of Oahu, and cabled to shore by 22.3 nm of cable. The analog recordings from Hydrophone 14 later were processed on the UNIVAC 1230 computer aboard SANDS.

Hydrophones 13 and 15 also are located in the same area. Both of these units, however, had cable faults introducing undesirable power frequency hum in the system and, therefore, were not used.

All data were recorded on an Ampex 1300, 14-channel, analog tape recorder. Three FM recording channels were used in parallel with each hydrophone. The gains of the three channels were staggered so as to obviate any necessity for gain changes during the operation and provided adequate dynamic range to permit undistorted peak amplitude as well as ambient noise measurements to be obtained.

In addition to the six acoustic channels, the following information was recorded: (a) the shot instant (Channel 8) signified by the disruption of the 1-kHz tone transmitted via radio from the source ship, (b) an IRIG Time Code (Channel 4), and (c) a voice track (Channel 6) for identification. The analog tape unit was run at 1-7/8 in/sec for both Phases 1 and 2, yielding a recording bandwidth of 0 to 750 Hz on the FM acoustic data channels and 100 to 7500 Hz on the AM channels.

A complete system calibration was made every 24 hr, in addition to spot calibrations at 30 Hz, 100 Hz, and 400 Hz every 2 to 4 hr or at tape reel changes. A calibration frequency at 177.5 Hz was added during Phase 2 to cover the CW source frequency.

In addition to the analog recording of data, hand analysis of the shot data was performed during the course of the experiment. The MILS Hydrophone 14 output was filtered by three band-pass filters (one octave at 31 Hz, one-third octave at 100 Hz, and one-third octave at 400 Hz), and the filter outputs were recorded along with the shot instants and time code on an 8-channel Sanborn paper recorder. Peak values were read from the Sanborn recorder for each shot in the various filter bands

and the range was determined for each shot by using the shot instants and signal arrival times. Propagation loss versus range was determined and plotted for each of the conditions shown in Table E-III. In addition, the frequency and level of the CW source in Phase 2 were monitored by using a Mod 5 LOFAR and 0.5- and 10-Hz band-pass filters.

Table E-III (U)
Data Sets Processed in Real Time Kaneohe

Phase	Shot Depth (ft)	Analysis Band Center Frequency (Hz)	No. of Shots Averaged
1	500	31	11
	60	31	11
	500	100	11
	60	100	11
2	500	31	2
	60	31	1
	2500	31	2
	500	100	2
	60	100	1
	2500	100	2
	500	400	2

Note 1: All 60- and 500-ft shots were 3-lb TNT blocks. All 2500-ft shots were SUS MK 59-4s.
Note 2: The 31-Hz analyses were in a one-octave band. The 100- and 400-Hz analyses were in a one-third-octave band.

5. Source Ship (Phases 2 and 3)

a. General

RADFORD was source ship during Phases 2 and 3 of the PARKA I Experiment. Phase 2 was a combined CW and explosive propagation run. RADFORD towed a CW source emitting a signal at 178 Hz at a depth of 500 ft along the PARKA I track from 22°N to 55°N at 157°50′W. The CW signal was continuous for 45 min during each hour. During the remaining 15 min, two charges were detonated at 2500 ft, one charge was detonated at 60 ft, and two charges were detonated at 500 ft. Twice each day a Pseudorandom Noise (PN) signal was sent during the period 40 to 45 min after the hour.

During Phase 3B, the return leg along the PARKA I track, four stations were made at selected points for the purpose of measuring signal coherence over various long base lines. For these measurements RADFORD transmitted pulses at 178 Hz and PN noise centered at 178 Hz. In addition to acoustic operations, sea surface temperature samplings were made every 2 hr and XBT's were taken every 6 hr. If more than a 2°C change occurred in the surface temperature when compared with the previous sampling, an extra XBT was taken at that position.

A bottom profile was taken along the PARKA I track during Phase 2, and the results were sent to Fleet Numerical Weather Central, Monterey, for interpretation.

b. Installation

Figure E-11 is a block diagram of the equipment installed on RADFORD at Pearl Harbor during the period 15 to 24 August 1968.

The AN/SQA-10 VDS transducer on board the ship was removed. The cradle was modified to handle the USL transducer fish assembly. The cable running inboard from the VDS winch was disconnected at the VDS junction box, and the USL cable from a helihut was mated to the VDS cable on the winch at this junction box. Six No. 22-wire leads were paralleled in each leg of the VDS cable to permit an adequate current carrying capability for energizing the Honeywell transducer.

The helihut containing the instrumentation for PARKA I was welded to the 01 level deck between the ship's stacks.

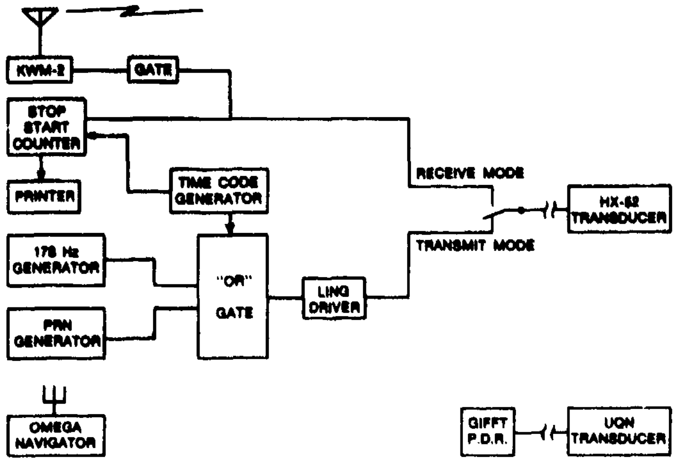


Fig. E-11 – RADFORD instrumentation block diagram (U)

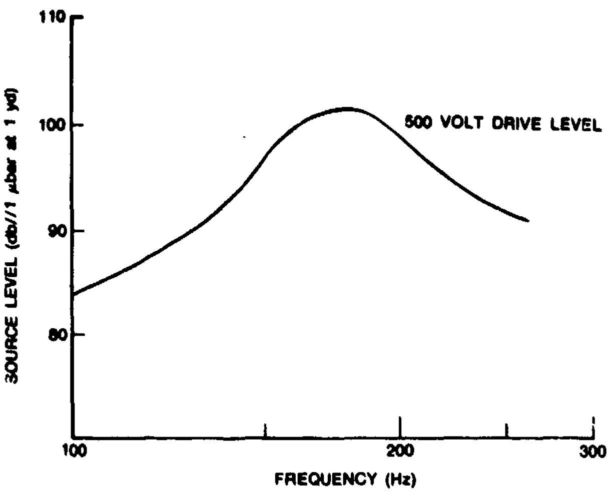


Fig. E-12 – Source level of 178-Hz projector (source depth 400 ft) (C)

c. **Instrumentation**

Explosive shots and CW and PN acoustic signals were transmitted for propagation, attenuation, and correlation measurements.

The CW and PN acoustic signals were generated by a HX-52 Honeywell Transducer, which was resonant at 178 Hz. This transducer has a maximum output level of 102 db//1 μbar at 1 yd for a CW signal. Its transmitting response characteristic is shown in Fig. E-12.

In addition to its transmitting sequence of CW and PN signals, during the 15 min prior to each hour the source was not energized. This "dead time" was set aside for ambient noise measurements at the receiving sites and for the utilization of the transducer in the receive mode as a hydrophone for picking up the five explosive shots for time zero detonation. The first two shots were SUS MK 59-4s set to detonate at 2500 ft. The last two shots were 3-lb TNT charges with appropriate fuse lengths to detonate at 500 ft. The third shot also was a 3-lb TNT charge deployed from the ship on a float with a line and soluble salt ring. Line length was 60 ft.

A continuous bottom profile recording for the PARKA I transit was made by using a Precision Depth Recorder (PDR). The Gifft Model GDR-1C-19T was tied in with the ship's fathometer. The PDR is a self-contained transceiver using only the transducer of the ship's fathometer. A means was provided to switch from the PDR to the ship's recorder when RADFORD desired to take a sounding.

A TRACOR Omega Navigation Receiver was installed in RADFORD's chart room for precision navigation. Although these readings were logged in periodically, skywave

corrections for the areas transited were not available and all position estimates during the experiment were obtained by Loran A, radar, dead reckoning, and celestial fixes. Omega corrections obtained after the experiment were used to obtain a better estimate of the ship's position.

6. Navigation of FLIP and SANDS

a. General

The navigation suite on SANDS consisted of the ship's Loran A, a Loran C, an Omega, and a satellite navigation system supplied by ONR. Point ALFA was located in a marginal operating area for Loran C, and the results from that unit proved unreliable. The Omega unit operated satisfactorily, but skywave correction tables were unavailable for the area of interest. However, Omega readings were logged in during the entire Phase 1 portion of the experiment with the expectation that the satellite navigation fixes could be used to obtain skywave corrections. However, at the beginning of Phase 2, the Omega receiver was transferred to RADFORD because she lacked suitable navigation for the experiment, and it was felt that skywave corrections could be generated after the fact. The Loran A operated satisfactorily in this area yielding very reliable daytime readings with an expected loss in reliability during the evening and periods near dawn and dusk. The most accurate system proved to be the satellite navigation system, which consisted of the Magnavox MX 702CA receiver, a Hewlett-Packard 2115A computer, and a Teletype ASR-33 teleprinter.

The Teletype teleprinter ASR-33 has a tape punch and reader unit. This teleprinter is capable of inputing data to the computer directly by the keyboard or by a prepunched tape. One of the disadvantages of this teleprinter is that its reading speed is only 10 characters/sec.

Just before the PARKA I operations, a Hewlett-Packard Model 2737A, high-speed, punched-tape reader was obtained to supplement the satellite navigation system. This instrument permitted loading a navigation program into the computer in 3 min instead of the 45 min required with the teleprinter.

During the PARKA I Experiment there were four active operational satellites in orbit. These satellites are in 600-nm, circular, polar orbits. Each satellite completely circles the earth in about 105 min. The satellite's memory system has a 16-hr capacity; however, memory injections occur about every 12 hr and, therefore, a satellite is never without a valid navigation message. This message is transmitted to the ground on two carrier frequencies, 150 MHz and 400 MHz. The message is continuous and repetitive and is timed to last exactly 2 min. The computer program requires three complete 2-min messages to obtain a fix or position. From one given position on earth, a satellite will pass at various elevations throughout the day. However, when a satellite pass is less than 10° elevation to the horizon or above 70° elevation, the position computed should not be regarded as a good reliable fix.

b. System Check-out Enroute to Hawaii

The satellite system was installed on SANDS three days before departure from New London on 1 July 1968 enroute to Yorktown, Va. During check-out, the receiver power supply failed and SANDS got underway by using a general purpose DC power supply to provide the receiver with the 28 V required for operation. In the 24-hr period prior to arriving at Yorktown, seven reliable satellite fixes were

obtained. At Yorktown, a new power supply was installed and the ship departed for the Panama Canal. During this portion of the trip only two navigational fixes were obtained, and the second power supply failed on the sixth day. The power supply failures were due to high cabin temperatures and poor ventilation in the cabinet that housed the receiver and power supply. These factors were corrected in Panama by installing an air conditioner in the room and adding another ventilating fan to the cabinet. However, another power supply could not be obtained before the ship's departure for Hawaii and further testing enroute was curtailed. In addition to the power supply failures, the computer program supplied by Magnavox failed and had to be reloaded everytime the ship's AC power would fade.

7. System Check-out in Hawaii

On 2 August, the new receiver power supply was installed at Honolulu and the Magnavox program was loaded into the computer. Testing over a two-day period yielded unfavorable results. On 4 August, a program written at the Applied Physics Laboratory (APL) of Johns Hopkins University was installed, and, although the results were favorable, they indicated that receiver difficulties still existed. Further receiver checks resulted in replacing circuit cards that may have been damaged by the high temperatures that existed in early July. From 6 to 9 August both programs were tested extensively. During this period, the Magnavox program continued to produce unreliable fixes and would have to be reloaded when ship's power faded or failed. The APL program resulted in repeatable fixes accurate to 0.1 nm for all satellite passes during its operation. In addition, power fades and failures did not necessitate reloading the programs. For these reasons the APL program was used during subsequent operations.

8. System Performance During the PARKA I Experiment

On 9 August, SANDS departed Honolulu enroute to the operating area 350 nm north of Hawaii. Satellite fixes were obtained during this transit period and were compared with Loran A. Passes within the required elevation range were plotted on an average of 0 to 1 nm from fixes obtained from Loran A. This comparison was made about 90 percent of the time during the operations and until the satellite receiver failed.

Between 10 and 29 August, 502 passes occurred. Of these, 339 passes were between 10° and 70° elevation, 28 passes were above 70°, and 135 passes were below 10°. There were 273 good fixes recorded. The remaining 66 good passes were missed for the following reasons:

(1) A power failure in the navigation center caused by overloaded radio equipment.

(2) Mutual interference generated by raising two satellites at the same time.

(3) Interference caused by a "sleeping" satellite coming to life.

(4) Data injections into satellite that restricted its transmissions.

The following is a breakdown of elevation in degrees versus the number of two-min messages sent:

(1) 10° to 12°–6 messages.
(2) 13° to 19°–7 messages.
(3) 20° to 63°–8 messages.
(4) 64° to 70°–9 messages.

On 29 August, nonnumeric characters were observed on the satellite data print-out. At first only a few appeared, but, as time

passed, these characters increased to such an extent that entire two-min messages were nothing but nonnumerics. This problem precluded obtaining fixes.

Various tests described in the operation and maintenance manual were conducted. The Doublet Rate phase comparator module was tested first, since a prior failure in this unit had resulted in this same problem. It was found that the 0.1-V signal was not present. There were several other tests performed, and they all led back to a problem in this module. With the satellite navigator out of commission, the remainder of the operation had to be conducted by using Loran A.

9. PARKA I Track Charts

Figures E-13 and E-14 are the navigation plots for Phases 1 and 2, respectively. The tracks are annotated with date-time groups and symbols that describe the operational mode of FLIP and SANDS during various portions of the exercise. Note that during all of Phase 1 and at the beginning of Phase 2 the plots run smoothly and are derived from satellite navigation fixes. Also, all abrupt changes in movement can be explained by the change in the tethered configuration of FLIP and SANDS (e.g., anchor lost, tether parted, reanchored). On 29 August the satellite receiver failed. From then until 5 September, Loran A was used for navigation. This portion of the track exhibits some erratic tendencies with the decreased precision afforded by the Loran A in comparison with the satellite navigation equipment.

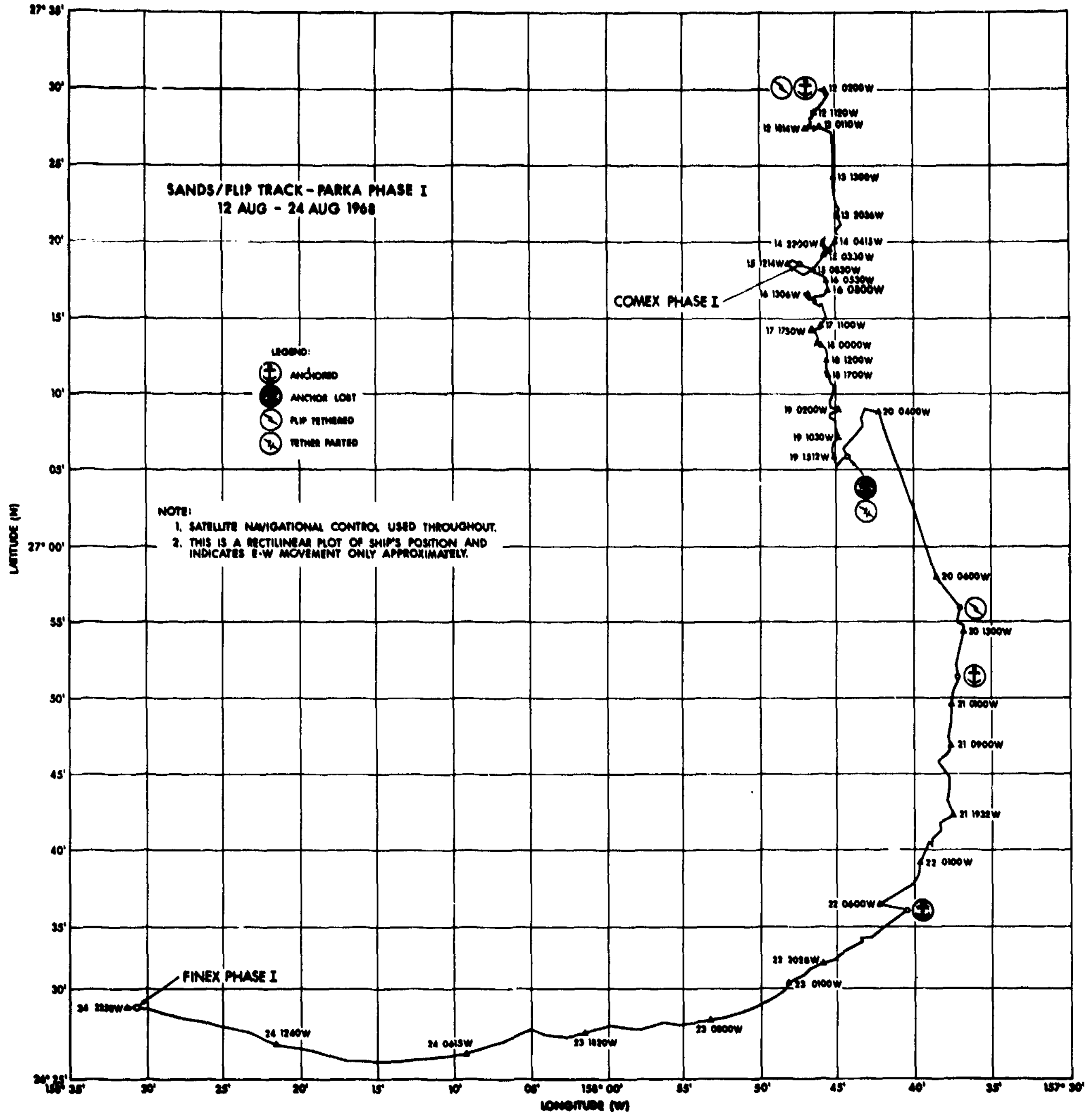


Fig. E-13 – FLIP/SANDS track – PARKA I Phase 1
12-24 August 1968 (U)

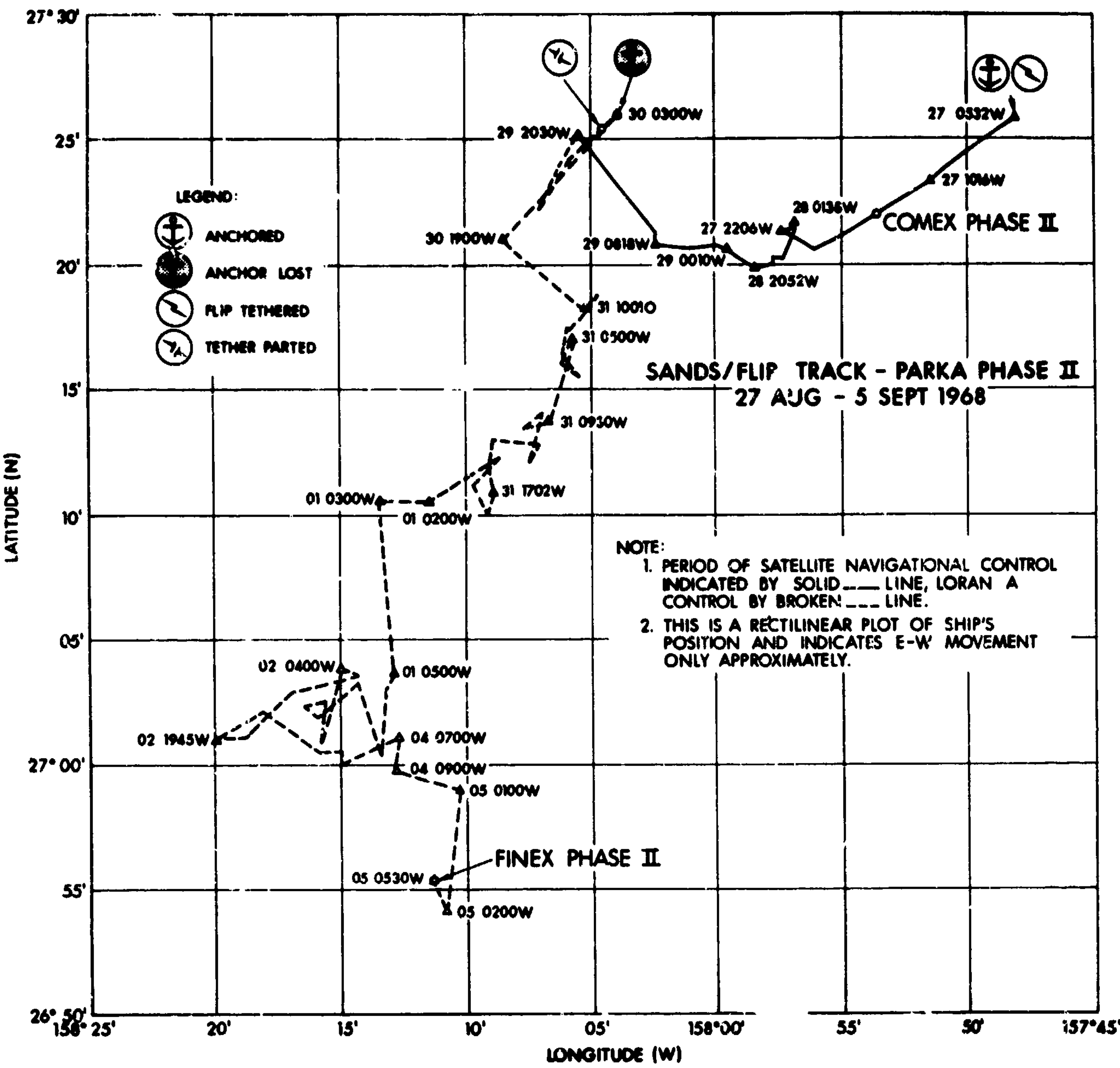


Fig. E-14 – FLIP/SANDS track – PARKA I Phase 2
27 August-5 September 1968 (U)

Appendix F (U)

NRL MEASUREMENTS OF BOTTOM REFLECTIVITY AND LONG BASELINE CORRELATION

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Naval Research Laboratory

1. Bottom Reflection Measurements

a. Objectives

The purpose of the experiment was to measure the reflection coefficients of the bottom along the PARKA I track as a function of angle of incidence at several frequencies between 50 Hz and 5000 Hz. It was expected that the data would give some evidence of the nature of the reflection process as to whether the reflection was primarily specular or nonspecular. In addition it was planned that the nature of fluctuation over very long paths be measured.

b. General Nature of Experiment

One-way propagation measurements were made using 3-lb TNT explosive sources, and recordings were made of the bottom reflected pulses. The angle at the bottom was varied by having the source ship open range from the receiving ship. The source depths for all runs were 1000 ft and receiving hydrophones were placed at depths of 500 ft and 1000 ft.

Three types of runs were made. Run A was an opening range run from approximately 1 kyd and 60 kyd which gave grazing angles for the bottom reflected path from about 90° to 1/2°. The angle for the second bottom reflection varied from 90° to about 14°. Fifty shots were fired on this run at ranges which would give equal increments of reflection angle. Runs B1 and B2 were constant range runs at 30 and 10 kyds respectively, with reflection angles of about 15° and 50°. Twenty shots were fired in rapid succession on each run to give a measure of signal fluctuation.

Runs B1 and B2 of each station were recorded at very long ranges at PMR Kaneohe, at PMR Midway, and at the U.S. Naval Facility, Point Sur for purposes of long range coherence studies.

c. Location

Three positions on the PARKA I track (157°50'W) were selected as representative of the wide range of bottom conditions. Acoustic and oceanographic data were collected at each position.

Station 3A1, 52°30'N, had a flat smooth bottom consisting of a very thick sediment, 700-800 meters thick, overlying the subbottom. This sediment was highly stratified. No sea mounts were known to exist within hundreds of miles.

Station 3A2, 46°05'N, had a semithick sediment 200-300 meters thick. Its surface was smooth and it was well stratified. Sea mounts existed in the vicinity. None

were discovered which would interfere with the experiment. The position of this station was moved north 20 miles from the planned position to avoid a large sea mount.

Station 3A3, 24°30'N, was a region where sea mounts were characteristic. The bottom was very rough with little (<100 meters) or no sediment

d. **Ships**

The transmitting platform was R/V MIKI-MIKI, a privately owned sea-going tug chartered by the Hawaii Institute of Geophysics for PARKA I participation. The receiving platform was R/V CONRAD, from the Lamont–Doherty Geological Observatory.

e. **Schedule**

Installations on CONRAD and MIKIMIKI were made in Kodiak, Alaska 7-9 September 1968. Most of the equipment had been put aboard in Honolulu, Hawaii. Both ships departed Kodiak 2100W, 9 September, and had the following time schedule:

1800W	11 Sept	Arrived station 3A1
0314W	12 Sept	Commence Run A
1518W	12 Sept	Commence Run B1
1812W	12 Sept	Commence Run B2
2200W	14 Sept	Arrived station 3A2
0255W	15 Sept	Commence Run A
0906W	15 Sept	Commence Run B1
1254W	15 Sept	Commence Run B2
1900W	22 Sept	Arrived station 3A3
2029W	22 Sept	Commence Run A
0448W	23 Sept	Commence Run B1
0647W	23 Sept	Commence Run B2
1400W	25 Sept	Arrive Honolulu

f. **Measurement Technique**

The acoustic sources were 3-lb TNT charges set to detonate at 1000-ft depth. The depth was controlled by the fuse length. Eight feet was determined to be the required length with 84.4 sec the burning time. A test series of shots showed the firing depth to be 1000 ft ±25 ft. On runs B1 and B2 of each station data for calibration of the shot source were obtained by lowering a hydrophone to 200 ft and recording on one channel of an FM tape recorder. The hydrophone was an Atlantic Research Model LC-50 with sensitivity reduced to −128.5 dB with a parallel 1.0 μf capacitor. The recording equipment consisted of a calibrated attenuator, a 30-dB gain broadband amplifier with roll off below 50 Hz, and one channel of a Hewlett-Packard tape recorder recording FM at 15 ips and adjusted to 2.0 volts rms as the top of the dynamic range. The "blast time" on all shots was transmitted by radio for acoustic range determination.

On CONRAD, two hydrophones were placed at 500 and 1000-ft depths on soft suspensions. The hydrophones were Model H54 designed and fabricated by the Underwater Sound Reference Division, NRL, for purposes of this experiment. They consisted of an electroacoustic element made up of 3 magnesium-capped PZT-4 ceramic cylinders connected electrically in series and coupled to a transistor preamplifier. The overall sensitivity was −84.0 dB with 6 dB per octave roll-off below 50 Hz. The preamp had a gain of 13.8 dB and output impedance of 35 ohms. A 10 ohm calibrating resistor was in series with the hydrophone crystal, and produced a calibration for the whole recording system after the crystal.

From each hydrophone the acoustic signals were fed through a calibrated attenuator, a 30 dB amplifier, and onto one channel of a tape

recorder. A second channel received the same signal boosted 30 dB. In addition to the four channels of acoustic signal, a 10 kHz CW signal, a time-code-generator signal, a radio shot blast, and edge channel voice were recorded. Recordings were made FM at 15 ips and monitored on an oscilloscope.

In all cases the attenuators were set to give a good record of the first bottom reflection. Where direct and second bottom reflection paths were not too different in amplitude from the first bottom reflection, they too were recorded.

The range between ships was determined for operational purposes by the radar on MIKIMIKI. For the opening range runs the procedure was to have MIKIMIKI open range from CONRAD at a constant speed and maintain an accurate plot of range vs time. When radar contact was lost the shots were dropped at times read from an extrapolation of the range plot. A record of the CONRAD radar ranges were made for comparison. For data analysis purposes the ranges as determined from the acoustic travel times will be used.

Satellite navigation was used on CONRAD so exact positioning of ships was known at all times.

g. Acoustic Data

It appears that we have good data which will permit plotting of bottom reflection loss in terms of peak amplitude, average, and power vs grazing angle at the ocean bottom from about 90° to 1/2° in one-third-octave bands from 50 Hz to 5000 Hz. Similar plots of second bottom reflection may also be made but it is impossible to predict how complete these will be. It was hoped a calibration of the sources can be made on the receiving ship by means of the direct path, but it is not known now whether these pulses fell within the dynamic range of the recording at short enough ranges for this purpose.

Data will be available for analysis to determine the physics involved in bottom reflection but it is not intended that this be a part of the first report. Three types of bottom, at least from the standpoint of sediment thickness, were measured using two hydrophones at different depths. A correlation of these records should be a basis for such analysis.

Data on fluctuation also are not reported here. At each station 20 shots were fired in rapid succession at each of two constant ranges. The pulse-to-pulse fluctuation from a fixed bottom could thus be measured. A study of the fluctuation of the bottom reflected signals as a function of angle could also be made.

Recordings of the shots were made at very long ranges at Kaneohe, Midway, and Point Sur. A study of signal coherence could be made based upon this data.

h. Oceanographic Data

At each station velocimeter casts were made at both ends of Run A by MIKIMIKI, with XBT drops from both ships on a regular 4-hour schedule. Cores of the bottom were obtained on each station by CONRAD, and on station 3A3 a thermogradient of the sediment was obtained. In addition, photographs of the bottoms were made and the concentration of particulate material and water currents were measured in the water close to the bottom.

In addition to the on-station data, both ships collected XBT's and MIKIMIKI occupied several extra velocimeter stations along the PARKA I track. CONRAD collected continuous bathymetry at two frequencies, 20-

200 Hz and either 3.5 kHz and 12 kHz, and a continuous magnetometer record.

The STD probe on CONRAD was not used due to a malfunction in the salinity sensor.

2. Long Baseline Coherence Experiment

a. General

The participation by the Acoustics Division, Signal Processing Branch in the PARKA I Experiment was designated PARKA I, Phase 3-B. The operations consisted mainly of propagating signals at long range, receiving them on several widely spaced hydrophones and recording them for later processing. Such processing would include crosscorrelation and other techniques for analyzing and combining the received signals. Part b describes the types of signals transmitted by RADFORD during Phase 3-B of PARKA I, and the manning of receiving sites. Part c describes in more detail the types of signals and intended applications of the received signals, as well as the results of some preliminary analysis.

b. Description of Phase 3-B

(1) Deployment of Source Vessel and Signal Transmissions

The source vessel, RADFORD, was deployed to five major locations along the PARKA I track for nine hours of transmission at each transmission station. The starting positions of these stations, along with the actual positions utilized appear in Table F-1.

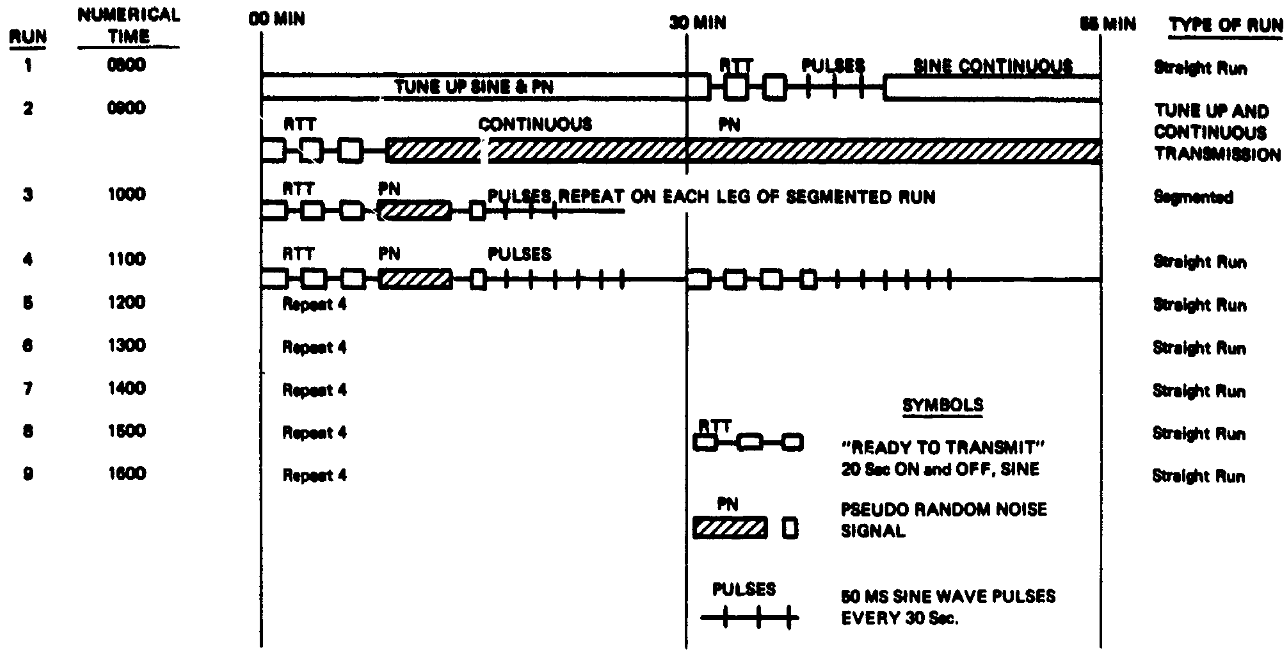
As may be observed, operations at four of the planned stations were actually accomplished and at locations near to those originally specified in the Operation Plan.

At each station RADFORD transmitted for nine hours, with runs consisting of sine wave and pseudo-random noise transmis-

Table F-I

Transmission Stations for Long Baseline Coherence Experiment (U)

Station	Date	Position	COMEX	FINEX
3B1	9/10/68	(Omitted due to bad weather)		
3B2	9/11/68	46°06'N 157°43'W	9/11/68 1515W	9/12/68 0027W
3B3	9/13/68	50°00'N 157°45'W	9/13/68 1315W	9/13/68 2214W
3B4	9/14/68	27°46'N 157°48'W	9/14/68 1800W	9/15/68 0240W
3B5	9/15/68	27°00'N 157°50'W	9/15/68 1650W	9/16/68 0130W



NOTE: Times for sequence of events are not exact and cannot be used for velocity measurements, due to the inaccuracy of cam operated programmer.

Fig. F-1 – Acoustic transmission for RADFORD (U)

sions as shown in Figure F-1. The first two hours of transmission were performed with the ship stopped in the water to eliminate Doppler effects. It consisted of continuous sine and PN transmission of up to 45 minutes each. The next hour was devoted to a circular or segmented run, as shown in Figure F-2. This run was for the purpose of generating various Doppler shifts at various receiving points. The next six hours were devoted to a series of runs repeated every half hour including several minutes of PN signals and extended periods of short sine wave pulses. A more complete description of the types of signals transmitted and the rationale for choosing them appears in Section C on the analysis of data.

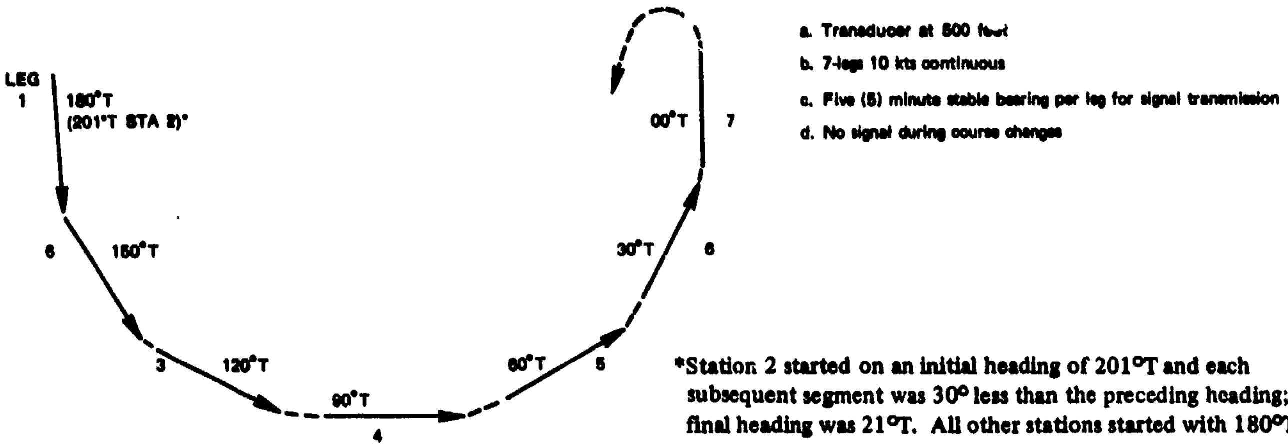
(2) Manning of Receiving Stations and Recording

For reception of the signals propagated by RADFORD, NRL personnel manned three stations. They consisted of the PMR Stations at Kaneohe, Hawaii, and Midway, and at the U.S. Naval Facility, Pt. Sur, California.

NRL personnel rode RADFORD during Phase 2, starting 26 August from Hawaii and arriving at Kodiak on 6 September to test the signal generating electronics and to make short transmissions to assist evaluation, in conjunction with Kaneohe-Midway receivers, of proposed transmission station locations for the return track (Phase 3).

During Phase 3, other NRL personnel rode RADFORD to operate the NRL transmission equipment. USNUSL maintained overall scientific responsibility for the RADFORD transmissions during Phase 3, including the loan of a heli-hut, projector and driver.

The recording sites were manned during all signal transmissions and complete recordings were made except for Station 5 at Midway, where it was felt that more effective



*Station 2 started on an initial heading of 201°T and each subsequent segment was 30° less than the preceding heading; final heading was 21°T. All other stations started with 180°T.

Fig. F-2 – Plot of segmented run (U)

use of personnel and equipment could be made at Kaneohe.

The tapes which were made on special portable recording facilities supplied by NRL at each station consisted of 7 track FM recordings including timing (WWV) and frequency standard (portable 1,000 Hz frequency synthesizers) signals. Also included was one channel processed by pre-recording filtering for use with very weak signal reception. Various combinations of hydrophones and arrays were recorded to gather data with versatile signal processing capabilities. The recording of the 1000 Hz frequency standard signals on all tapes will make it possible to combine the resulting tapes without loss of signal accuracy due to individual tape recorder flutter or speed variations. This will be accomplished by utilizing the recorded 1 kHz signal to synchronize the sampling positions for laboratory digital conversion before data analysis. By this means, an accurate crosscorrelation can be made between data collected at points of 2000 miles or more separation.

In the next section plans for analysis of the signals will be described, along with greater detail regarding the choice of signals for transmission.

c. **Analysis of Data**

In the following paragraphs are described the various signal transmissions made during the PARKA I Experiment and the projected methods used for analysis. Since the analysis and interpretation of the large volumes of data collected are time consuming, only a small portion of the results are available at present, however, some observations will be made regarding the quality of recorded signals. In addition, some recordings were made of shots detonated during Phase 3-A. These recordings have been analyzed in a preliminary manner and comments will be made on these results.

(1) Intended Analysis of Phase 3-B Signals

(a) Sine continuous, transmitted 20 min once per operating day (178 Hz)

This signal was recorded at all three stations, representing single frequency transmission over three widely separated paths simultaneously.

Analysis will be made of chart recordings (Sanborn) to determine amplitude stability, and of magnetic tape recordings to obtain both amplitude stability and phase

stability. By means of a cumulative phase meter developed by NRL, it will be possible to observe both very short and long term phase stability of each path.

(b) Pseudo-random Noise (PN) transmitted 2-1/2 minutes each half hour and 40 minutes continuously once a day, filtered to 178 Hz.

This signal was recorded at intervals of one-half hour at each of the three receiving locations. It consists of a short PN sequence, 1023 bits, shifted at 800 Hz, generating a PN period of 1.28 seconds. There are many ultimate applications of these signals, a few of which are as follows:

1. Long baseline coherency measurements:

Utilizing very accurately controlled frequency references, it is possible to combine the tapes made at the three locations and to cross correlate them in receiver pairs. The result is a measure of the coherency observed between those two receivers and how it varies at intervals of one-half hour. Previous studies have shown little variation over two-minute intervals and large variation over one-hour intervals, hence the choice of half-hourly intervals for this experiment. Although the bandwidth of these signals is limited to less than one octave, which probably leads to higher correlation coefficients than might be observed for broadband signals, it is felt that the results are relevant to real life situations since any received signal can be limited to these bandwidths.

2. Single path coherency measurements:

Similar to the above, except that a laboratory PN generator, suitably compensated for Doppler, is used to cross correlate against the incoming signal. This gives an indication of the degradation of the signal over a single path.

3. Signal Design Studies:

Using PN and similar classes of signals, a study of the properties of various signals for use in active sonar, with regard to average power, Doppler sensitivity, and ambiguity can be undertaken.

4. Transmission Bandwidth:

Since the spectrum of PN signals is virtually flat up to the first null (which occurs at the shift rate) a filtered portion of the signal takes on the frequency spectrum of the filter. The filtered signals used here have a finite bandwidth, and by making a spectrum analysis of the received signals it is possible to determine the attenuation characteristics of the intervening acoustic path as a function of frequency. The daily transmissions of a 40-minute continuous PN signal make it possible to observe the fluctuations in transmission versus frequency (over the band transmitted) as a function of time.

(c) Pseudo-random Noise transmitted for five minutes continuously on each leg of a segmented run (see Figure F-2).

These signals were received and recorded at each of the three locations, with varying Doppler shifts depending upon the particular leg of the segmented run and the angle it made with each receiving site.

These signals will be used to test various Doppler compensation schemes for multiple receiver (Long Baseline) processing. They will also be used to investigate the ambiguity function relationships of transmitted PN.

(d) Narrow sine pulses (approximately 50 ms) transmitted 20 minutes per half hour for the last six hours of the operating day.

This signal was recorded at all three listening stations intermittently on magnetic tape. It will be used to examine the multipath structure that existed close in time to the half-hourly PN transmissions, and also to monitor changes in transmission characteristics over the last six hours of the operating day.

(2) Signal-to-Noise Ratio of Received Signals

It was possible to receive most of the transmitted signals at each of the three locations. The received signal-to-noise ratio varied, however, from one transmission station to another at each receiving location. A detailed analysis of these variations will be made from the tapes to determine the variation of signal transmission from each transmission position to each receiving location. However, certain generalizations can be made based on observations of NRL personnel at the receiving sites.

Signal-to-noise ratios were generally significantly poorer than those observed in similar experiments previously conducted in the Atlantic basin. This is, no doubt, at least partly due to the tremendously increased ranges encountered in the Pacific, since the transmission power utilized was identical. Also of interest, however, is the different topography and thermal structure of the Pacific which it is believed exerted an additional influence. For example, it was observed that north-south transmission (transmission from colder to warmer regions) was superior to south-north transmission.

The signals themselves were also a significant variable determining the reception strength. The best signal reception was obtained with the continuous sine wave signals. These were also received during the 20-second-on, 20-second-off "Ready-to-Transmit" pulses which accompanied every change in transmission made. The reception of the Pseudo-random Noise was almost on a par with the sine wave transmissions, however, the short sine transmissions (50 ms pulses) were usually not received at all except for the closest ranges. Even the 20-second sine transmissions were blurred or stretched out with their starting and ending times not well defined. At these ranges, apparently the number of paths is great enough to cause a blurring rather than discrete identifiable paths experienced during shorter range propagation. If this is correct, then the longer transmission is necessary to build up a sufficient number of transmission paths to provide a useful received signal-to-noise ratio. More importantly, it implies that PN, especially with a sequence length of 20 seconds or so, should be an appropriate signal for study of these many paths by providing sufficient energy to be propagated while still preserving the accurate time resolution needed by later correlation with laboratory generated PN.[1]

(3) Correlation of Shot Data

During Phase 3-B another experiment (Phase 3-A) was also being conducted involving acoustic shots. It was possible to record some of these shots on magnetic tape at the three receiving sites for later analysis. Some of these tapes have already received preliminary analysis because of the interest in observing possible correlation over relatively short baselines. The signals, which were recorded on FM tape from two hydrophones

[1]For a description of this method of studying multipath see "Long Baseline Correlation Experiments," by Peterson & Coulter, Proceedings of 25th NSUA November, 1967.

about 1500 ft apart, were converted to digital form in the laboratory and cross correlated against each other. A very definite correlation spike was observed, the value of the normalized cross-correlation coefficient being about 0.5. Further study of these data will be made to test correlation at wider hydrophone separations.

In summary, a considerable quantity of useful data was obtained in tape recorded form during participation in Phase 3-B. Preliminary rough observations on signal propagation and received strength, and the results of preliminary analysis of acoustic shot data are presented. Results of future analysis of the data will be reported subsequently.

DEPARTMENT OF THE NAVY
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800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

IN REPLY REFER TO
5510/1
Ser 93/160
10 Mar 99

From: Chief of Naval Research
To: Commander, Naval Meteorology and Oceanography Command
1020 Balch Boulevard
Stennis Space Center MS 39529-5005

Subj: DECLASSIFICATION OF PARKA I AND PARKA II REPORTS

Ref: (a) CNMOC ltr 3140 Ser 5/110 of 12 Aug 97

Encl: (1) Listing of Known Classified PARKA Reports

1. In response to reference (a), the Chief of Naval Operations (N874) has reviewed a number of Pacific Acoustic Research Kaneohe-Alaska (PARKA) Experiment documents and has determined that all PARKA I and PARKA II reports may be declassified and marked as follows:

   Classification changed to UNCLASSIFIED by authority of Chief of Naval Research letter Ser 93/160, 10 Mar 99.

   DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

2. Enclosure (1) is a listing of known classified PARKA reports. The marking on those documents should be changed as noted in paragraph 1 above. When other PARKA I and PARKA II reports are identified, their markings should be changed and a copy of the title page and a notation of how many pages the document contained should be provided to Chief of Naval Research (ONR 93), 800 N. Quincy Street, Arlington, VA 22217-5660. This will enable me to maintain a master list of downgraded PARKA reports.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

Peggy Lambert

PEGGY LAMBERT
By direction

Copy to:
NUWC Newport Technical Library (Code 5441)
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ʀKA II Acoustic Results, 16 December 1969, USL-PUB-6001, NUSC New London, 106 pages
ɩUSC NL Accession # 006001)

PARKA II Interim Report, 18 December 1969, Contract N00014-69-C-0088, Bell Telephone Labs, 129 pages
(NRL SSC Accession # 85007061)

PARKA II-B ONR Scientific Plan 1-70, 15 January 1970, MC Report 04, Maury Center for Ocean Science (ONR), Unknown # of pages
(NUSC NL Accession # 051663)

Environmental Oceanographic Observations in Support of PARKA II-A Operation, 30 April 1970, HU-HIG-ITR-4, Hawaii Institute-Hawaii Institute of Geophysics, Unknown # of pages
(NUSC NL Accession # 058081)

PARKA II-A Bottom Loss Measurement, 29 June 1970, USL-R-2408, NUSC New London, 19 pages
(NUSC NL Accession # 002408) (DTIC **# C008 441**)

PARKA II-A Bottom Loss Measurement, 29 June 1970, USL-2211-023-70, NUSC New London, Unknown # of pages
(NUSC NL Accession # 185457)

PARKA II-A Experiment, Final Report - Final Draft, Volume 1, The Acoustic Propagation Measurements, 30 June 1970, Contract N00014-69-C-0088, Bell Telephone Labs, 81 pages
(NRL SSC Accession # 10013937)

PARKA I: Software Procedures Report, 1 July 1970, NUSC/NL Technical Memorandum No. 2211-033-70, NUSC New London, 109 pages
(NUSC NL Accession # 116963) (NRL SSC Accession # 85009135) (DTIC **# C008 091**)

PARKA II - A Briefing Report, November 1970, MC Report 004, Maury Center for Ocean Science (ONR), 32 pages
(NUSC NL Accession # 055573) (NRL Accession # 474985) (NRL SSC Accession # 85007058)
(DTIC **# 513 631**) ✓

PARKA I Experiment, Appendices, January 1971, MC Report 003, Volume 2, Maury Center for Ocean Science (ONR), 165 pages
(NRL Accession # 480369) (NRL SSC Accession # 85004880) (DTIC **# 517 075**)

Sound Propagation Through the Northwest Pacific Emperor Seamount Chain, 15 April 1971, 11 pages
(DTIC **# 519 151**) ✓

PARKA II-A, The Acoustic Measurements, August 1971, MC Report 006, Volume 1, Maury Center for Ocean Science (ONR), 118 pages
(NUSC NL Accession # 023515) (NRL Accession # 483765) (NRL SSC Accession # 85004882)